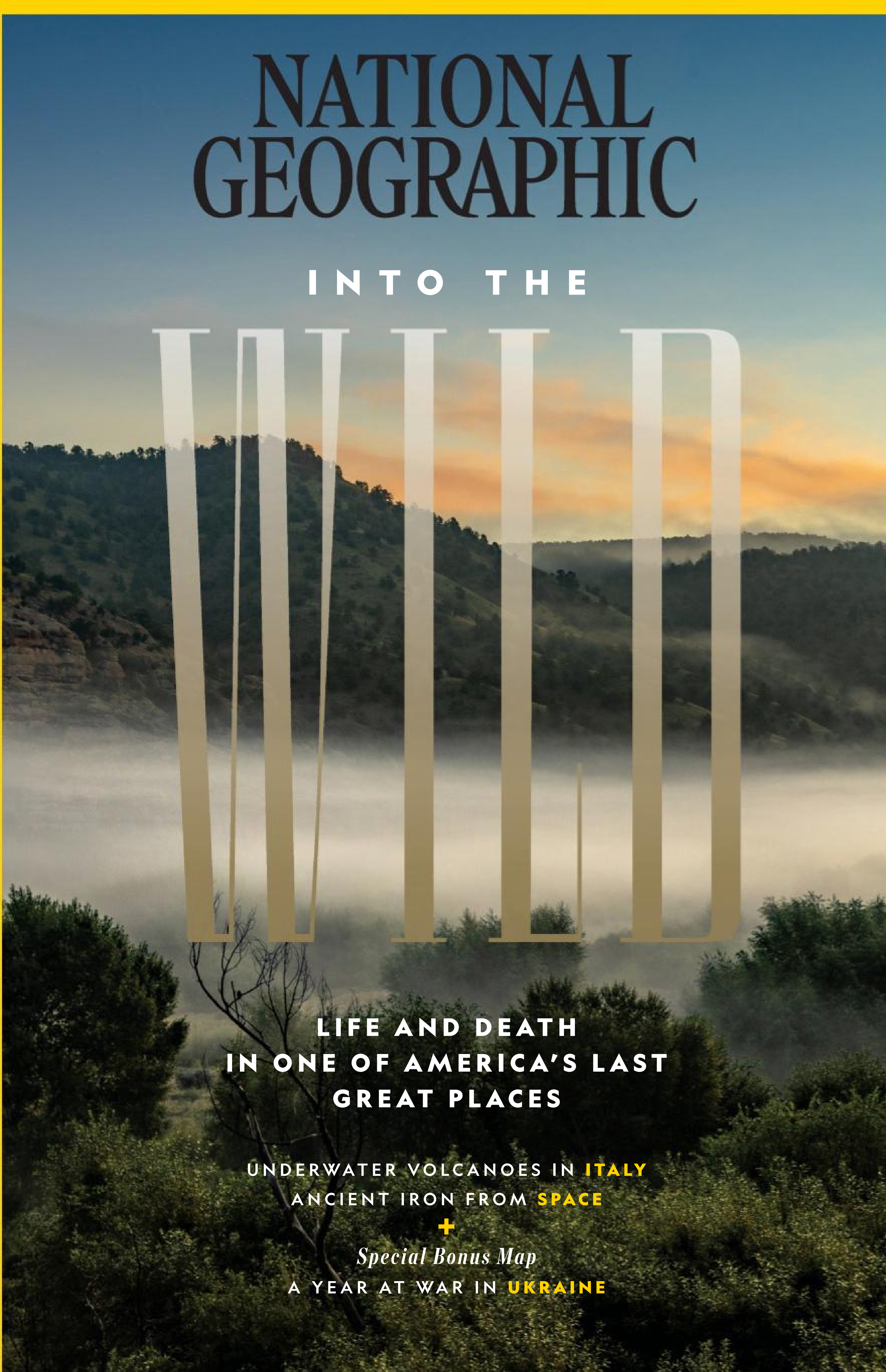
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NATIONAL GEOGRAPHIC
INTO THE
WILD
LIFE AND DEATH
IN ONE OF AMERICA'S LAST
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ANCIENT IRON FROM SPACE
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PHOTOGRAPHS BY CODY COBB

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A packhorse finishes its workday and grazes in the high country of the Gila Wilderness in New Mexico. There are no roads in this wilderness area, and no mechanized vehicles are allowed, but visitors can explore its rugged expanses by foot or on horseback.

BY **NATHAN LUMP** PHOTOGRAPH BY **KATIE ORLINSKY**

THE ONGOING PROJECT of protecting natural lands and waters isn't a uniquely American effort. But it's one that the United States has enshrined and elaborated to a greater degree than any other country on the planet.

Our world-famous national parks have captured imaginations for more than a century (the federal system was established in 1916). My friend Conor Knighton has traveled to every single park, a journey he documented in his 2020 book, *Leave Only Footprints*. The rest of us can virtually visit some this month when a new season of National Geographic's series *America's National Parks* begins streaming on Disney+.

Of course, there are other federally protected areas. National marine sanctuaries. National wildlife refuges. National monuments. National forests. For this issue's cover story, writer Peter Gwin and photographer Katie Orlinsky take us deep into the Gila Wilderness in New Mexico, which upon its creation in 1924 was the first officially designated wilderness area not only in the United States but also in the world. The idea was the brainchild of the great American conservationist and ecologist Aldo Leopold, who believed in the value of preserving some environments in an entirely natural, unaltered state.

But is there any place on Earth that humans have left *truly* unaltered? What does it mean for places to be "wild," and what is our reference point for determining if they are? These are just some of the questions raised by the piece, and they take on even greater importance as, increasingly, countries all over the world seek not only to preserve wilderness but to re-create it, by "rewilding" land previously used for agriculture and other purposes.

Our cover story is just one of this month's fascinating pieces. We've got volcanic seascapes, ancient cultures using iron from meteorites before they could make it themselves, a matriarchal village in Brazil, and more.

We hope you enjoy the issue.



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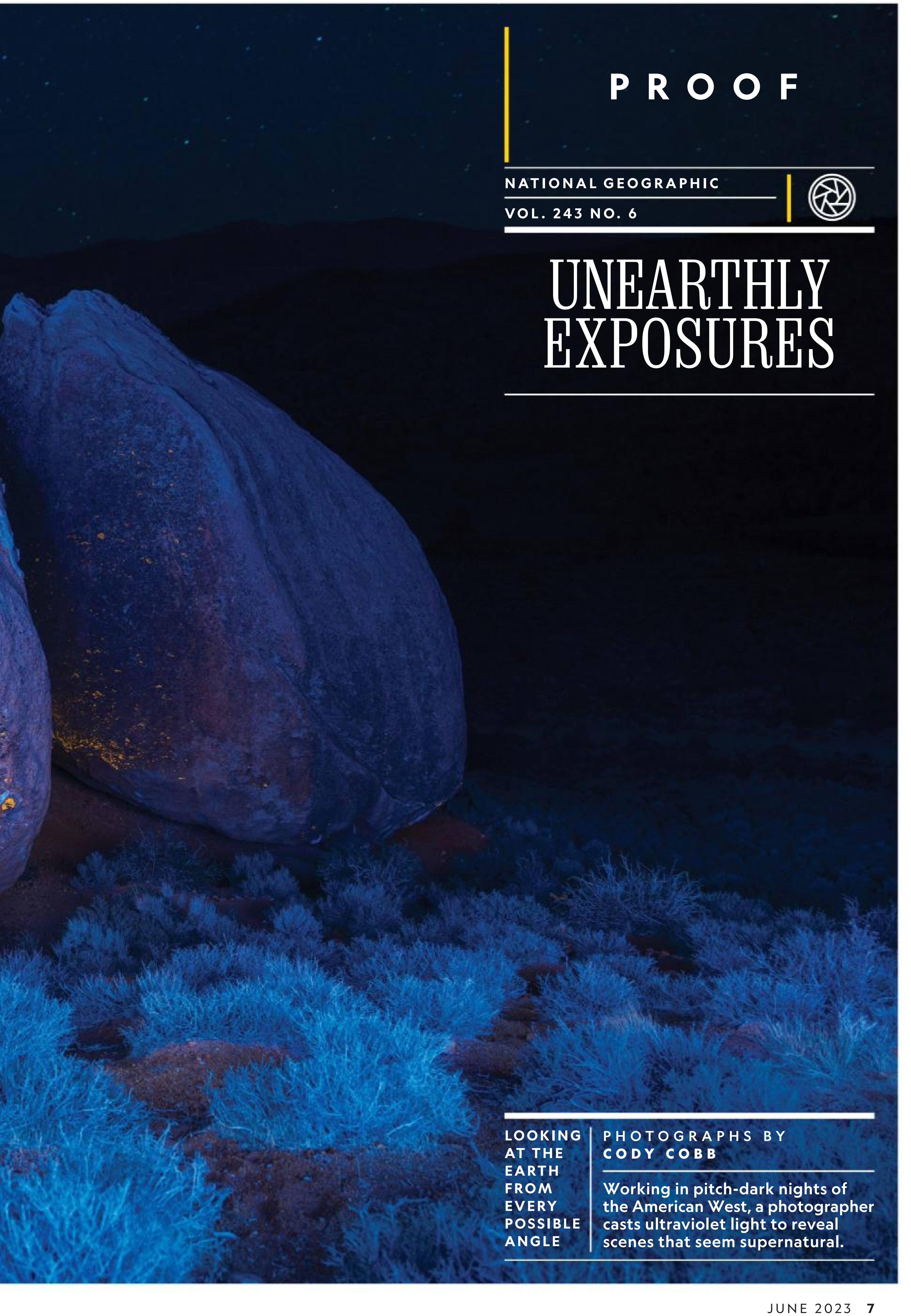
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DELIVERING FOR AMERICA



In this composite of two images, lichen looks like flecks of gold clinging to the north face of 55-foot-tall boulders—known to rock climbers as Grandma and Grandpa Peabody—in the foothills of California's Sierra Nevada.



PROOF

NATIONAL GEOGRAPHIC
VOL. 243 NO. 6

UNEARTHLY EXPOSURES

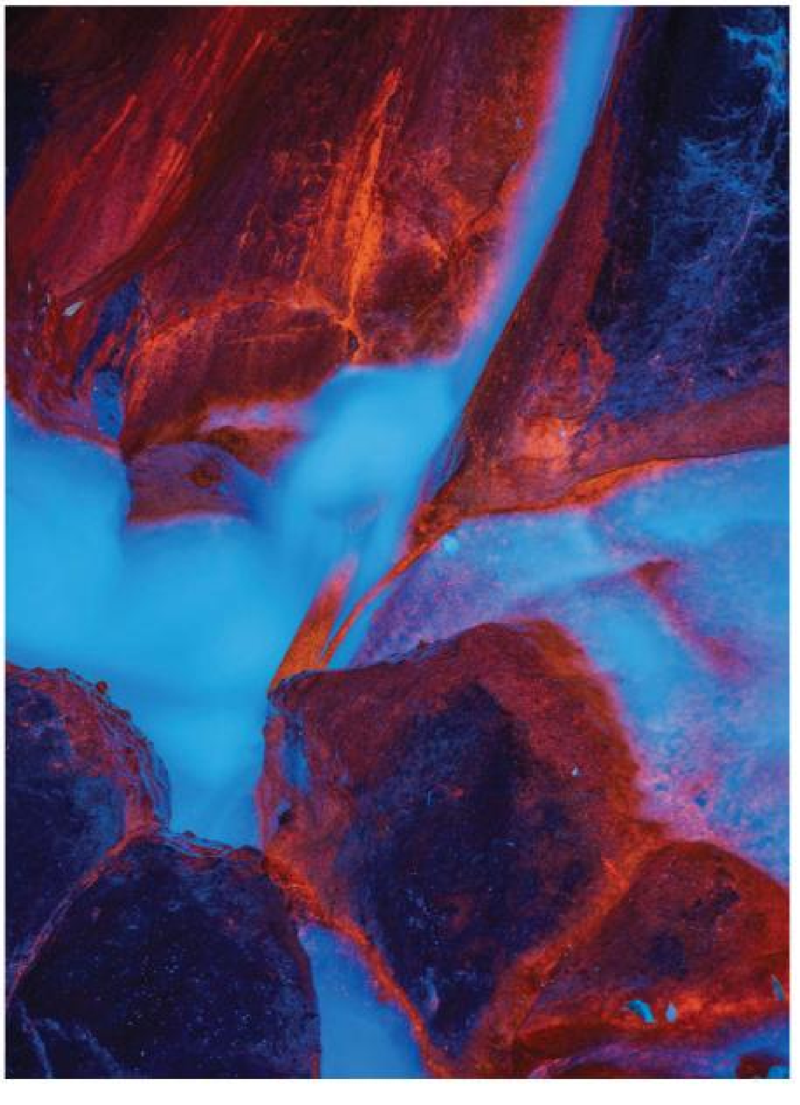
LOOKING AT THE EARTH FROM EVERY POSSIBLE ANGLE

PHOTOGRAPHS BY
CODY COBB

Working in pitch-dark nights of the American West, a photographer casts ultraviolet light to reveal scenes that seem supernatural.

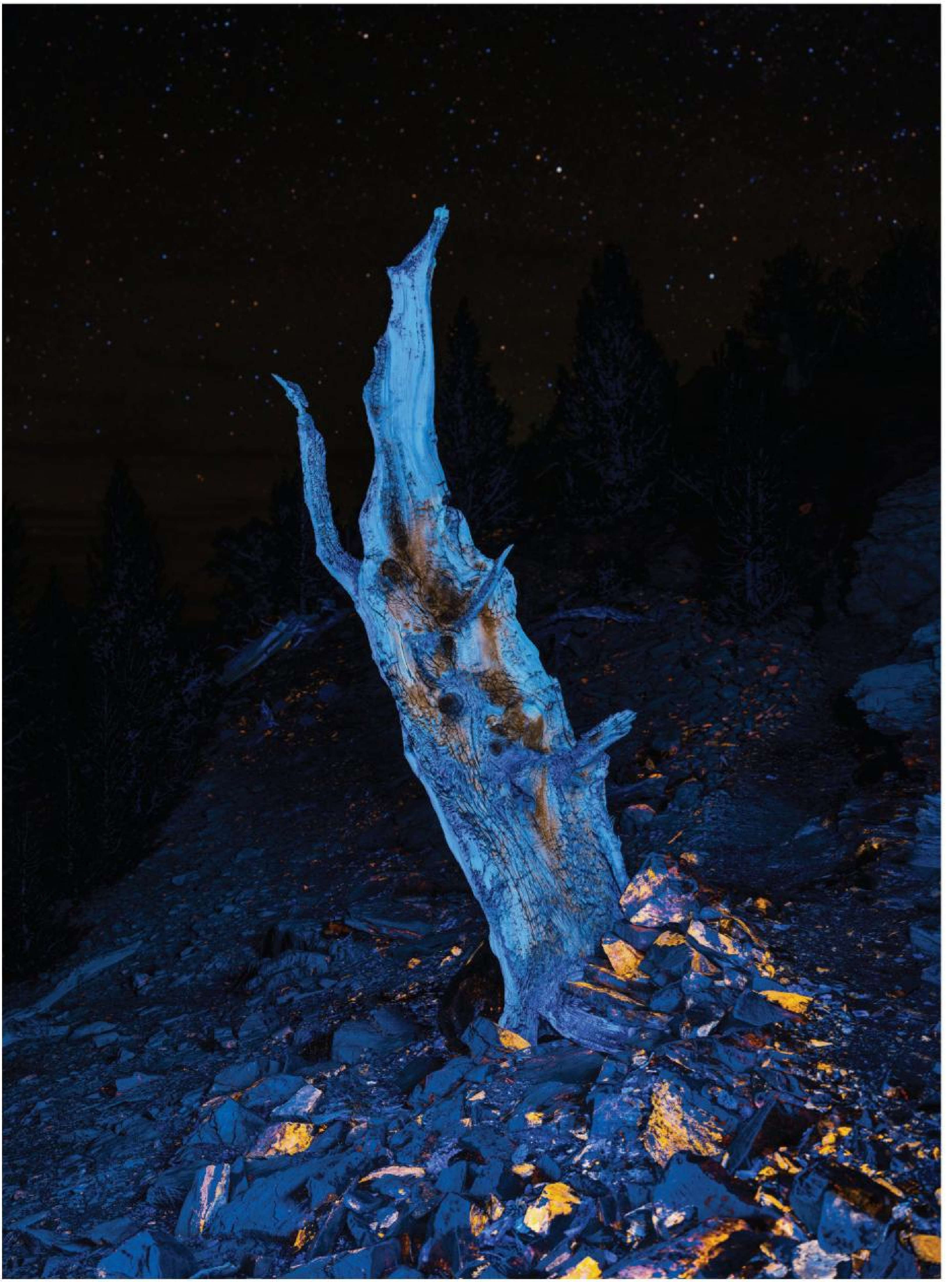








In the Cascade Range in Washington State, UV light shows striking hues in fir trees and lake algae (top left and right) and a rocky creek (bottom left). The bank of California's Mono Lake gets an eerie glow in this two-image composite (bottom right).



High in the White Mountains in California, a dead bristlecone pine tree is transformed into a sapphire blue apparition. “For a location that can be so brutal with high winds,” Cobb says, “I felt lucky to have perfect conditions.”



Weathered rock formations in the San Juan Basin in northwest New Mexico look otherworldly in this composite of two images. "What I was most surprised by in this photo was seeing so much color in a landscape that is normally



monochromatic: lots of soft gray clay and muted brown sandstone," Cobb says. Minerals and bits of petrified wood are half-buried beneath the sediment in this remote part of the Ah-Shi-Sle-Pah Wilderness, fluorescing like an azure sea.

THE BACKSTORY

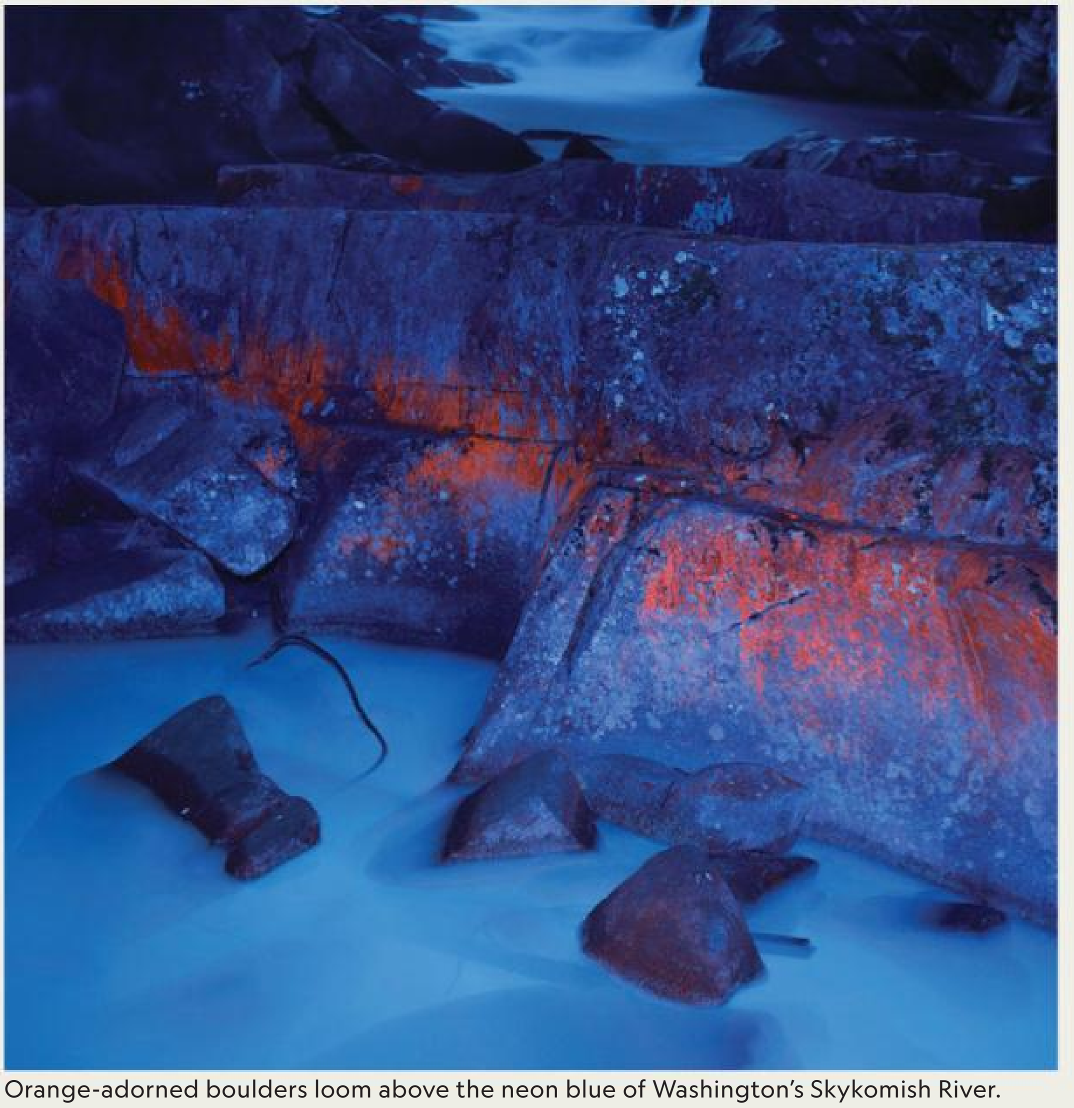
HE EXPERIMENTED WITH A NEW LIGHT SOURCE AND FOUND THE HIDDEN LUMINESCENCE IN CLASSIC U.S. LANDSCAPES.

AS NIGHT BEGAN TO FALL after a day of hiking and photographing on Washington State's Mount Rainier, Cody Cobb considered heading home. But instead, he reached for something in his bag—a gadget he'd tossed in with his gear on a whim. He had never used the ultraviolet light and decided to try a few shots for fun before packing up.

What Cobb saw in his viewfinder was so mesmerizing he ended up staying on the mountain until 4 a.m. By setting his camera on a slow shutter speed, anywhere from 30 seconds to four minutes, and waving the light in front of his subject, he discovered "a parallel world" not normally visible to the human eye.

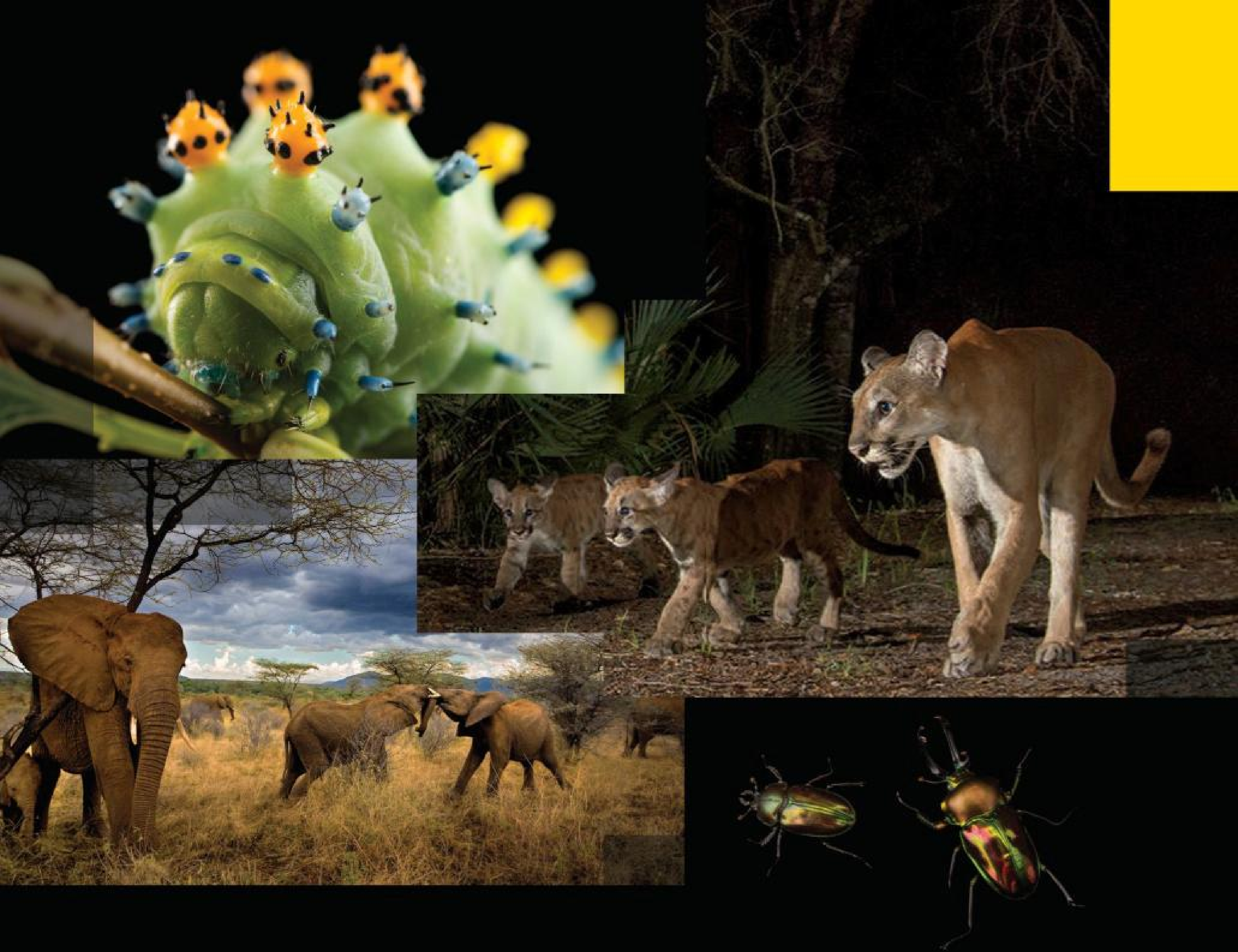
A self-taught photographer originally from rural Louisiana, Cobb grew up playing video games and reading science fiction. He became infatuated with the scenery of the American West after he moved to Seattle for a job. "I'd never been in a place that was so big," he says. Today Cobb feels at home in nature's expanses, spending weeks alone in the wilderness and using his camera to reveal its alien aspects.

—CATHERINE ZUCKERMAN

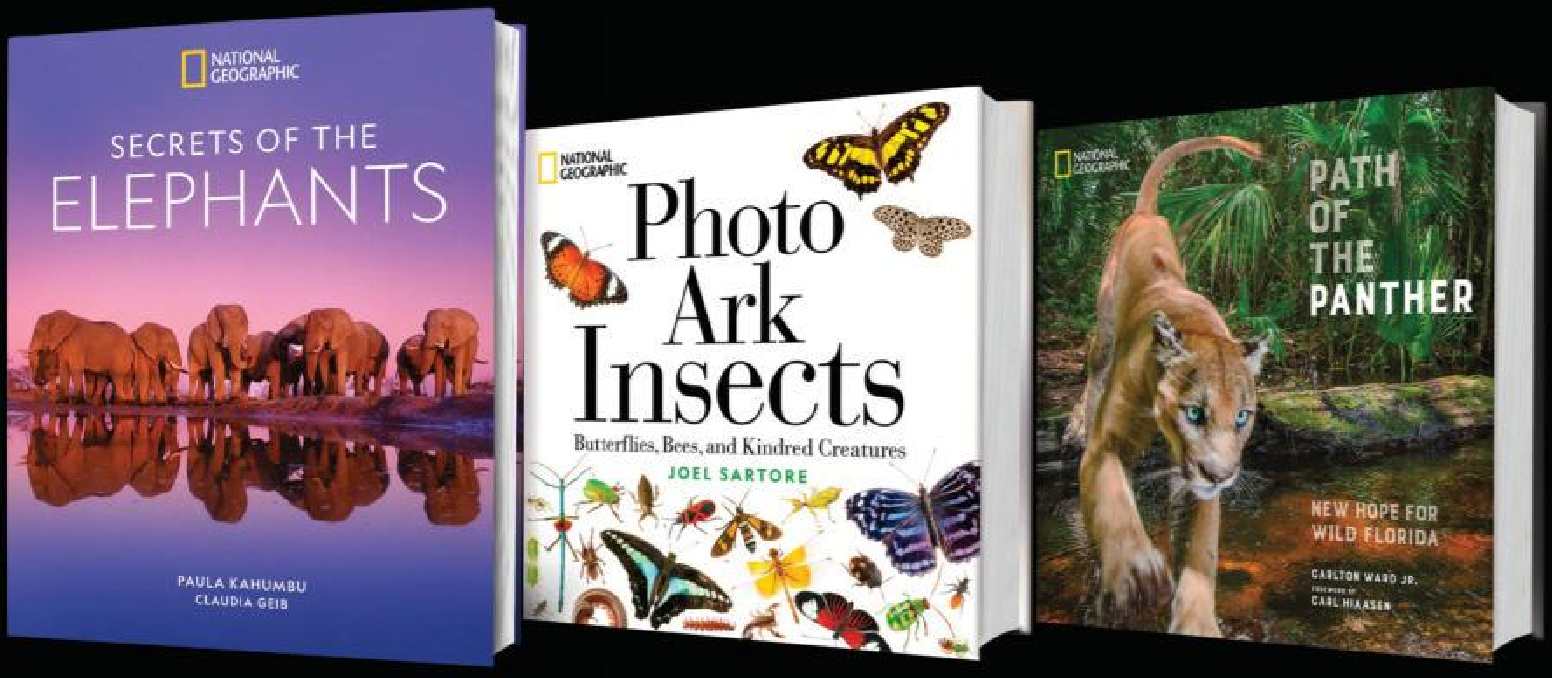


Orange-adorned boulders loom above the neon blue of Washington's Skykomish River.


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'We Can Tell These Truths'

NIKOLE HANNAH-JONES OF *THE 1619 PROJECT* DISCUSSES SLAVERY AS 'THE FOUNDATION ON WHICH THE COUNTRY IS BUILT.'

BY **DEBRA ADAMS SIMMONS**

N

NIKOLE HANNAH-JONES grew up in Waterloo, Iowa, where most of her family still lives. As an 11-year-old she wrote a letter to the editor of her local newspaper about a presidential primary. In 2017 she received a MacArthur Foundation fellowship, known as the "genius grant," for her work on educational inequality. Close ties to her community contributed to a thirst to share deeper knowledge of the American past and present, which place the enslavement of Africans at the center of the American story.

To commemorate the 400th anniversary of the beginning of slavery in what would become the United States, Hannah-Jones created an extensive project that examined 1619—the year the first enslaved Africans landed on the shores of the British colony of Virginia and were sold to settlers.

The 1619 Project, published in 2019 by the *New York Times Magazine,* set out to reframe U.S. history by exploring the legacy of slavery—and by explicitly

‘IT’S NOT JUST SAYING, “LET’S TEACH YOU ABOUT A HISTORY THAT HAPPENED A LONG TIME AGO,” BUT “LET’S TEACH YOU HOW THAT SLAVERY AND ITS LEGACY IS SHAPING AMERICA TODAY IN WAYS THAT WE DON’T KNOW.”’

identifying slavery as the foundation on which the country is built.

The project drew both praise and criticism among historians and political leaders, and it sparked a national discourse.

Hannah-Jones, who now teaches at Howard University, founded the school’s Center for Journalism and Democracy, where students can dig further for historical truths. “Our world is so small when it comes to Black folks,” she says during an interview for the *Overheard at National Geographic* podcast. “We don’t even know there’s all this history that we can learn because we think if it existed, someone would teach it to us or movies would reflect it, our monuments would reflect it.”

This interview has been condensed and edited for clarity.

Can you talk about how your vision has evolved from the *New York Times Magazine* project to the book, and now to an incredible multipart documentary?
It’s been a crazy and amazing and, really, just an inspiring journey for me. When I first pitched *The 1619 Project,* I just had an idea to take over an issue of the magazine and dedicate it to excavating the modern legacy of slavery. Out of that one idea, it grew to a special section of the newspaper as well as the magazine, and a six-part narrative podcast series. Once it went into the world, there was a response of so many people who said, “I never knew this history.”

I had never been prodded to contemplate the way that slavery is foundational in shaping society today. That’s really what the project argues. It’s not just saying, “Let’s teach you about a history that happened a long time ago,” but “Let’s teach you how that slavery and its legacy is shaping America today in ways that we don’t know.”

I’ve thought a lot about my family back home in Waterloo who want this information. But, you know, it’s hard to sit through 10,000-word essays, and this just makes it so much more accessible to the regular folks that I want to reach with this message.

We wish we had had more space and time to add more voices. We were able to really do that with the book. And, of course, we ended up doing two books.

Even before the book came out, we also were contacted by studios that said, “We want to develop *1619* into a host of different projects.” And the first offering of that, which is the most natural offering, is *The 1619 Project* docuseries.

Was there something in the public response that made you say, “You know what, I want to revisit this part?”
My original essay in the project is on democracy. And yes, I was very excited to be able to revise it, mostly because of all of the criticism and attacks that the essay received. Particularly the attacks around an argument I make about the American Revolution, which is that in the southern colonies, slavery played a major role in the white colonists deciding they wanted to join the Revolutionary effort.

Even though that argument about the American Revolution became this flash point, to me it was just one small fact in an essay that was going from 1619 to the present time. So if you read the revised essay in the book, you’ll see I now spend thousands of words making the case about the role of slavery in the Revolution. And the beauty of that was I did get to respond in good faith to criticisms that were made in good faith. I also got to respond to criticisms I felt were made in bad faith.

Did you imagine that *1619* would be the beginning of a pathway to a center for democracy?
The 1619 Project was a launchpad for my being at Howard. It was important when this project became so politicized to not just go to Howard and secure my own position but to use that moment to create something much bigger; to ensure that other *1619*-like projects and works, and reporting, could go into the world, because we will be training Black journalists to do historically informed investigative reporting.

Students at the high school and college level are like, “This book means so much to me. I’m realizing everything I wasn’t taught, and I want to learn more because this is just the tip of the iceberg.” And Black students, in particular, find themselves affirmed as agents in the American story—not just people who have been acted upon, not just people who’ve been oppressed, but agents who are driving the American story.

That has been transformative for a lot of students. And what’s beautiful is that this project allows me to introduce the work to regular people, whether they be students or my uncle who works at the John Deere plant in Waterloo.



PHOTO: REBECCA HALE, NGM STAFF

How does *1619* create a pathway for more media organizations, historians, and others to tell a broader American story?
I think the power of *The 1619 Project* is it proves what many of us have always known but that our editors don't often understand: If you put resources behind projects like this, and if you try to tell the truth unflinchingly, people will come to it.

People want complexity. They want intelligence. They want something that explains a society in the way our reporting too often doesn't. That's how I hope it will open doors.

There are many ways we can tell these truths and broaden this understanding of America where we've all gotten such a narrow understanding that it's so narrow as to be a lie. This project speaks to the silences. I would love to see a similar project done around Indigenous people.

Do you think that the timing impacted the growth of *The 1619 Project* beyond the initial plan?
Had this 400th anniversary fallen under the Obama administration, for instance, would people have been drawn to the project in the same way? I don't think so.

We had banished the legacy of slavery finally with the ascension of a Black man to the presidency. So why are we looking back and excavating that stuff? But then we follow the first Black president with a white nationalist president, and everyone has whiplash.

And so, people who are trying to grapple with how does this same country produce these two things within that short period of time, I think were looking for something in *The 1619 Project* to help explain this country. And then, of course, we get the protests of 2020, the so-called racial reckoning, which, you know, has now spawned another racial reckoning in the opposite direction.

What does the book-banning conversation, which largely has been centered around *1619*, tell you about the power of the project?
The way you change your society is by helping people better understand it and by changing the narratives that justify inequality. Any society where power feels under attack, they target the storytellers. If they weren't worried that it was having an impact, they wouldn't care.

So it is extremely affirming. The project is just getting bigger and bigger. And now with the documentary series, even more people are going to be able to start to make connections with the world they've built, that they live in. The scariest part is that the unequal country we have is being misshapen by the legacy of slavery. The legacy doesn't just hurt Black people and it never has. Our entire society suffers.

Talk about how your family and community have embraced the work.
You know, Waterloo is my hometown. A few years ago, it was named the worst place in America to be Black. To see the success I've had by telling our stories means so much to my family personally. These are just humble folks who never expected that anyone from our clan would become what I've been able to become. And what's so important to me is people understand that my community built me. My community gave me what I needed to be able to succeed.

hulu

An expansion of the print version of *The 1619 Project*, the six-part docuseries is now streaming on Hulu.

What do you think your father would say if he could see where you are now?
My father and my Uncle Eddie, my dad's brother and my closest uncle, both passed years ago. They would be so astounded by everything that's come. One of my proudest moments in this is that when you open the book, the first image you see is of my dad. In that picture of my dad, he's in Germany. He was 17, 18 years old; he had joined the military. He always said he felt freest when he was abroad because that was the only time he really felt he got treated like an American.

I always say America killed my dad and my uncle. My uncle died at 50 years old from cancer that went undiagnosed because he didn't have health insurance even though he worked every day. My dad was a man of stunted ambitions his entire life. He was one of the smartest people I knew. He was an avid reader but never was able to get ahead, and just had terrible health outcomes. He died before he could get Social Security, like so many Black people in this country. And so to think that every ambition he had to swallow could produce me? I just think about that, I carry that with me all the time. Who am I doing this for?

Part of the power of the docuseries is that so many Black families see themselves in your story.
This is the American story of so many people, but that never gets told in this way. And that's who I did this project for. Of course, I invite everyone to learn this history and see these stories. This is for the descendants of American slavery.

The stories we tell are the stories of nearly every single Black person, no matter what wealth or status they have. It's both the tragedy of America and the beauty of our people. ▫

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Nikole Hannah-Jones, Pulitzer Prize–winning journalist and executive producer of *The 1619 Project,* was interviewed by **Debra Adams Simmons,** vice president of Diversity, Equity, and Inclusion at National Geographic Media, who previously served as executive editor for History and Culture at *National Geographic.*



PHOTOGRAPH BY ENRIC SALA

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DISPATCHES FROM THE FRONT LINES OF SCIENCE AND INNOVATION

Even-more-poison ivy
Climate change likely is making poison ivy more noxious. Plants raised with added carbon dioxide grow more vigorously and produce more potent urushiol, the oil that causes blisters. Meanwhile, the plant is poised to expand its range as it thrives in the disturbed habitats of new suburbs and roadsides. —DOUGLAS MAIN



STELLAR PHENOMENA

COUNTDOWN TO A KILONOVA

ASTRONOMERS PEER INTO A STAR SYSTEM'S FUTURE—AND SEE IT ENDING WITH A BANG.

Most of the elements that fill up the universe (and our periodic table) come from extreme cosmic explosions. One such kablooey, the "kilonova," yields many of the elements heavier than iron, including much of the universe's gold. Triggering a kilonova, though, takes a specific scenario: the collision of two neutron stars, the ultradense leftovers from stars that died in supernovae. What are these collisions' origin stories?

In a first, a study in the journal *Nature* has shown that a star system within the Milky Way is doomed to end in a kilonova. The system, known as CPD-29 2176, is 11,000 light-years from us in the Milky Way's outskirts. It consists of a neutron star with a circular 60-day orbit around a hot, spinning star 18 times more massive than our sun (illustration **1**). Astronomers estimate that only 10 such systems are in our galaxy right now—making CPD-29 2176 a one-in-10 billion find.

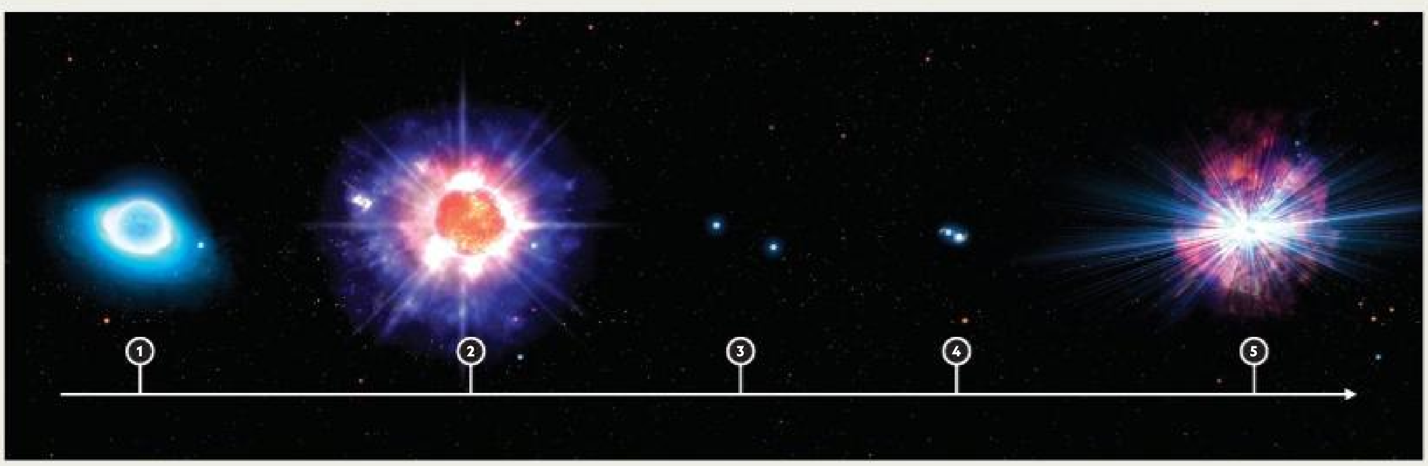
Over the next few million years or so, the gravity of the system's neutron star will strip off and eject much of its partner star's mass. The partner will then die in a supernova (**2**), and its remnants will form a second neutron star (**3**). Over another billion years, the two neutron stars will spiral into each other (**4**) until they merge and trigger a kilonova (**5**). This galactic fireworks display will create its own confetti: a sprinkling of newly formed heavy elements. —MICHAEL GRESHKO



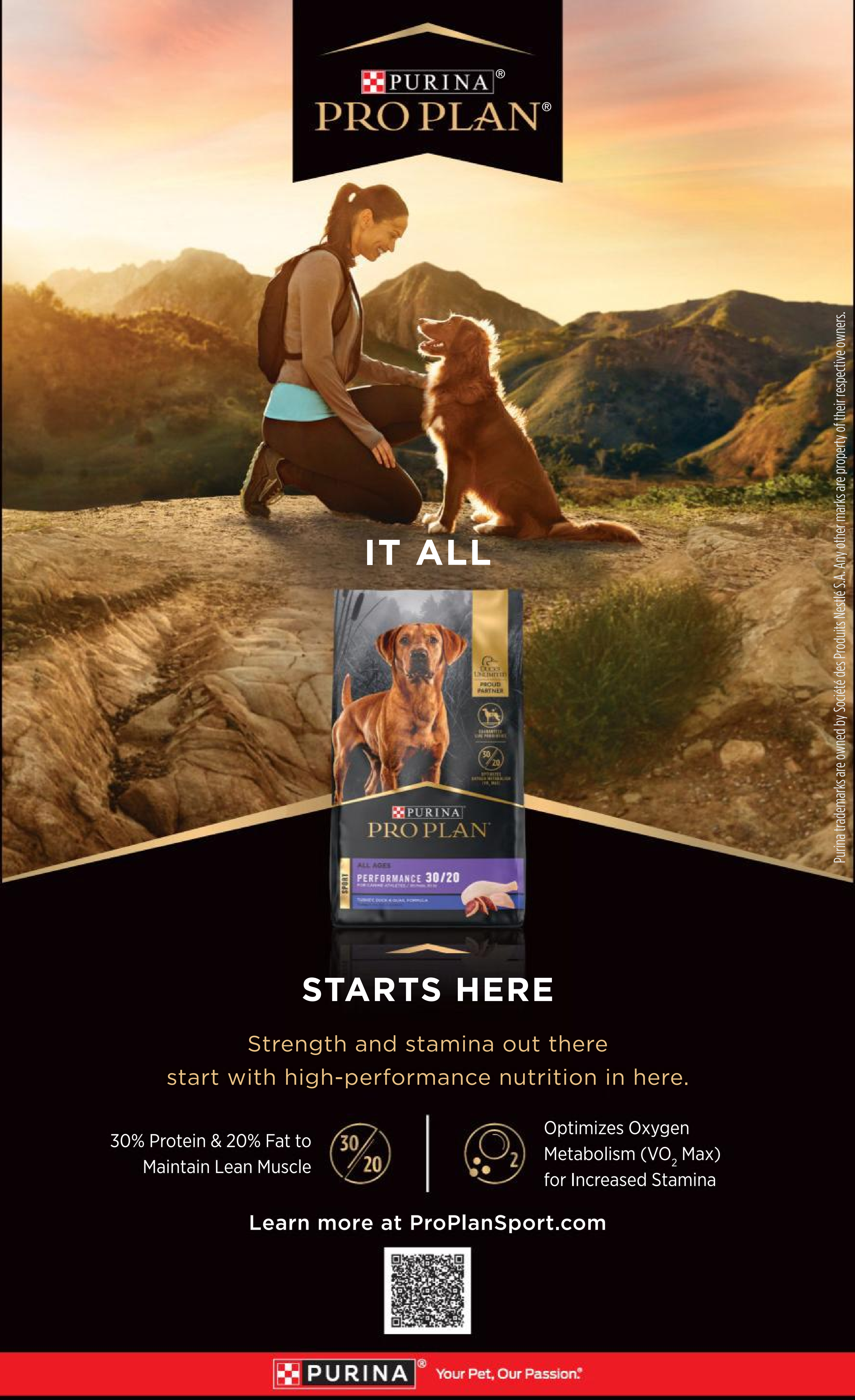
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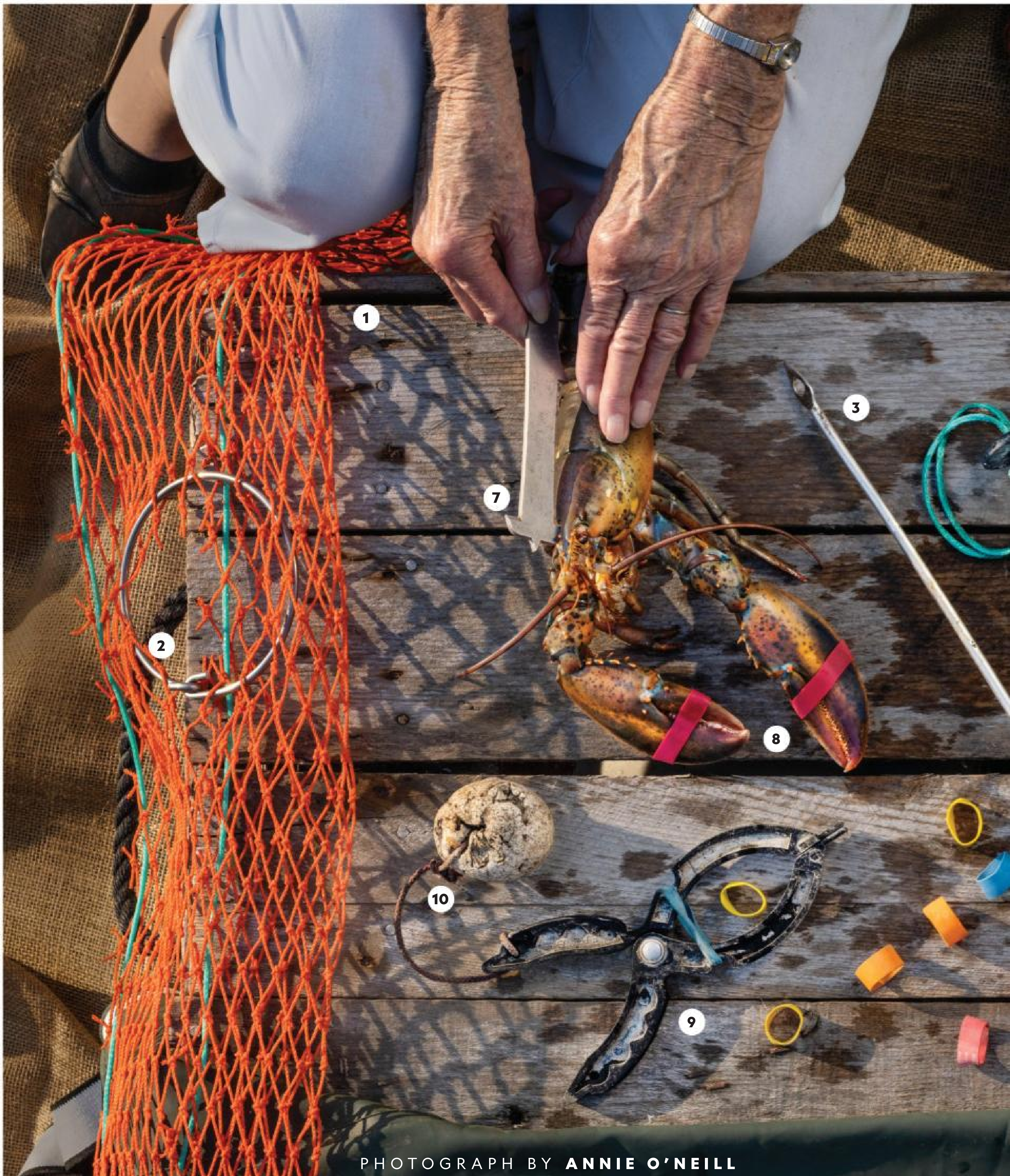
It breathes underwater via bubble

Earth's smallest scuba diver may be a Costa Rican lizard with a body roughly as long as a toothpick. When a water anole darts into streams to lose predators, a thin layer of air clings to its hydrophobic skin, creating a bubble from which it can breathe for at least 16 minutes. Some anole experts think oxygen from surrounding water may be permeating the bubble, replenishing the lizard's air supply and extending the time it can stay under.
—ANNIE ROTH



IMAGES: GETTY IMAGES/ISTOCKPHOTO (POISON IVY); LINDSEY SWIERK (ANOLE); P. MARENFELD, CTIO/NOIRLAB/NSF/AURA (CPD-29 2176 INFOGRAPHIC)


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PHOTOGRAPH BY **ANNIE O'NEILL**

THE BUOYS MARKING Virginia Oliver's lobster traps bear an ID number she inherited from her father. Now it's Oliver's son Max working 200 traps with her in Maine's lobster fishery—as 102-year-old Oliver has done across nine decades. The debate over how the fishery affects endangered right whales has cost Maine lobster its sustainable seafood rating in two major guides. But a half hour before daybreak in season, mother and son still are putting out to sea, greeting fellow lobstermen with a wave or shout. "I might just go until I die," Oliver says. "That's when I'm going to quit." –TED GUP



A LOBSTERING LEGACY

1. Lobster trap
Like the one shown here, earlier traps were made by hand with wood slats. Today most use galvanized plastic-coated wire.

2. Head
Lobsters enter the trap through a "head" built of metal rings and mesh.

3. Bait iron
This long tool reaches into traps to insert and secure bags of bait.

4. Bait bag
A mesh bag holding three or four fish draws lobsters into the trap.

5. Rope
Ropes are used to connect, locate, raise, and lower lobster traps. Fishing rope entanglement harms and kills sea species, and in 2022 a federal court ruling led to new regulations for Maine lobstering operations in the name of protecting endangered right whales. The industry says a right whale death has never been tracked to its gear; critics say that's because entanglement evidence is hard to trace. New regulations, on hold, would require limits on rope use, lobstering areas, and seasons.

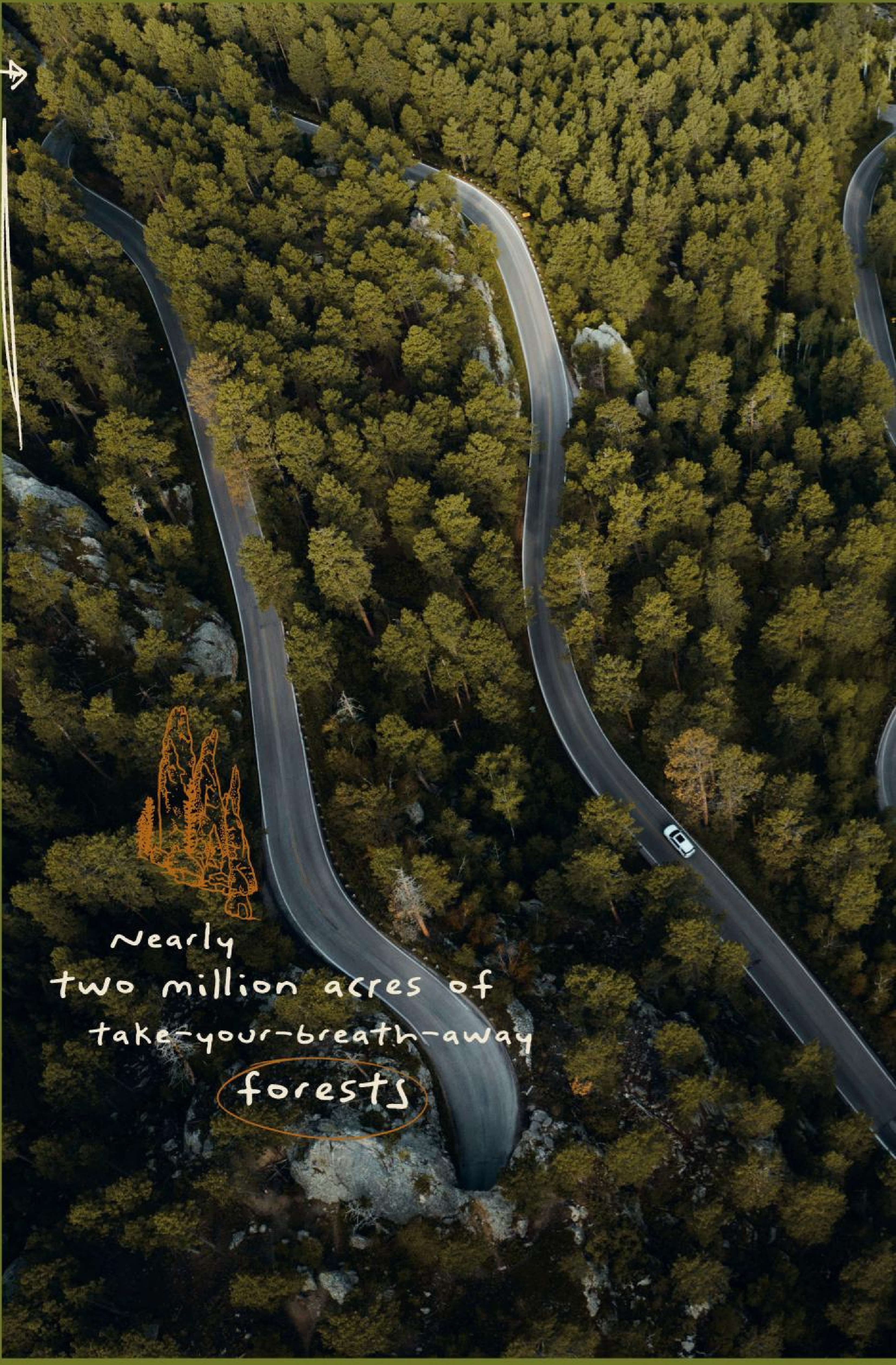
6. Buoy
Oliver's red and yellow buoys mark where her traps lie, some as deep as 20 fathoms (120 feet).

7. Measure, or gauge
Once a lobster is caught, this gauge ensures it meets the state size requirement.

8. Claw bands
Binding the claws with rubber bands keeps lobsters from pinching handlers or hurting each other during storage and shipping.

9. Banding tool
The device is used to put rubber bands on the claws.

10. Styrofoam fob
It's tied to the measure, making it easier to retrieve if it's washed overboard.


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forests


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SO LITTLE TIME


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Head *clavigero* Gianni Crea is in charge of 2,797 keys that access 300 doors throughout the Vatican Museums.

UNLOCKING THE VATICAN

EACH DAY, THE KEY KEEPER PROVIDES ACCESS TO THE HEALING BEAUTY FOUND IN ONE OF THE WORLD'S GREATEST ART COLLECTIONS.

BY **GULNAZ KHAN**
PHOTOGRAPHS BY **ALBERTO BERNASCONI**

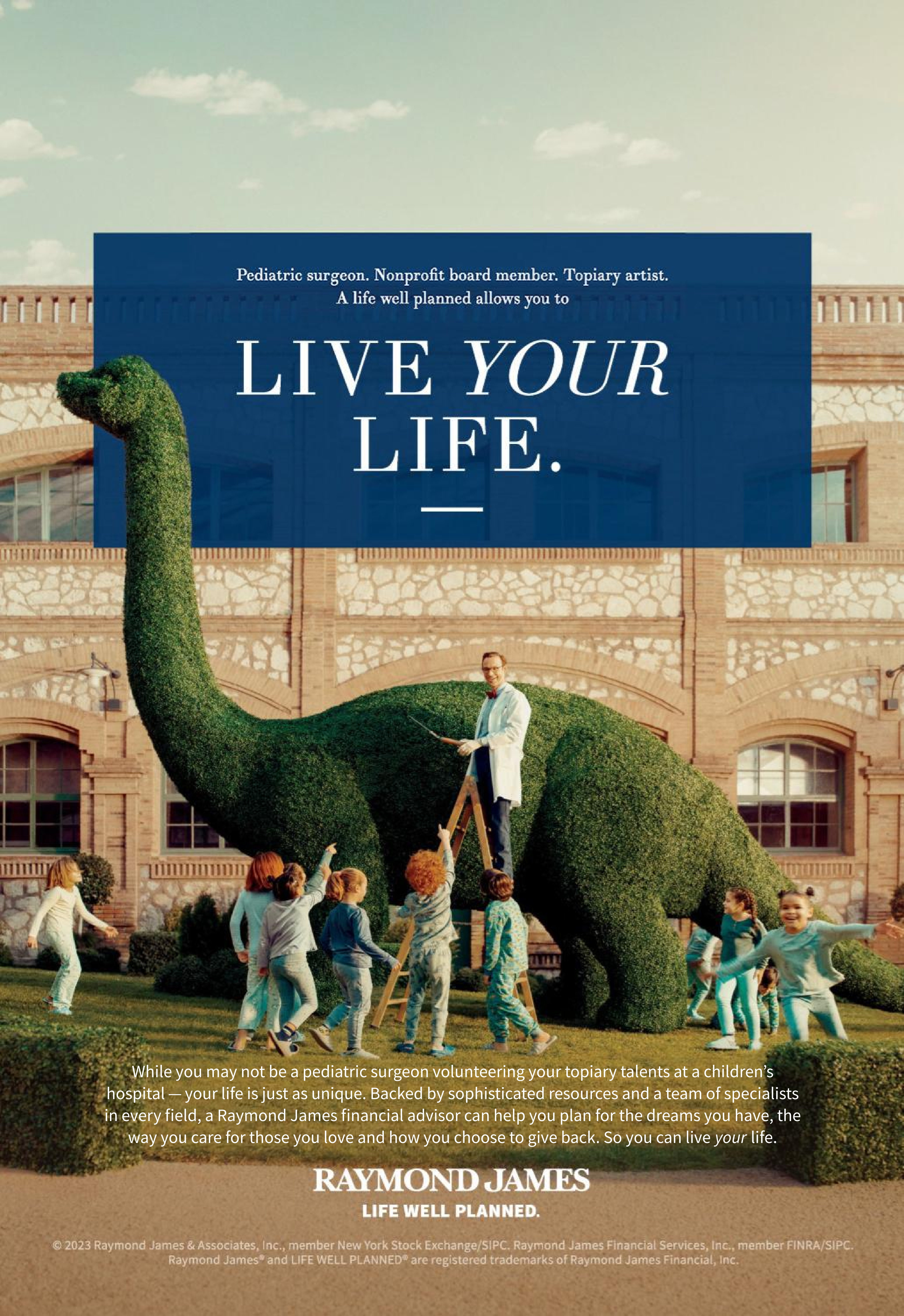
GIANNI CREA IS intimately familiar with the contours of history. Almost every morning for the past decade, he's unlocked the doors to the Vatican Museums. He's witnessed the splendor of the Sistine Chapel at dawn, studied the shadows of Caravaggio, and admired the textures of ancient Egypt.

"Yes, I'm a key keeper, head key keeper, but I'm still a doorman that opens a museum," says Crea, a devout Catholic. "But I open the doors to the history of art and the history of Christianity—and it's the biggest and most beautiful history that exists in the world."

His workday begins around 5 a.m. in a secure bunker that holds 2,797 keys. Crea and his team of 10 *clavigeri* navigate some 4.3 miles of passageways through the museums to reach 300 doors—many of them portals to vanished kingdoms and primordial gods.

"I know the smell that is waiting for me when I open the first door is the smell of history—the smell that men before us have breathed in," Crea says. Surrounded by the steady beat of his own solitary footfalls, he often marvels that the ground beneath him is the same one that generations have walked, loved, and cried on.

The Vatican Museums have housed papal collections since the beginning of the 15th century, including tens of thousands of precious artworks


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and archaeological artifacts spanning prehistory to modern times. But Crea believes that none are as striking as Michelangelo's Sistine Chapel, where 12,000 square feet of frescoes—including scenes from the Book of Genesis and over 300 figures—adorn the seat of the papal conclave. Crea recalls being overcome with emotion the first time he accompanied an older key keeper to open the chapel more than 20 years ago.

The figures are "so beautifully rendered in their details," Crea says. "The movements, the twisting, the musculature." He's witnessed people of all faiths being moved by the chapel's loveliness—something the church believes is increasingly vital in these turbulent times.

"In the difficult current context that the world is experiencing, in which sadness and distress sometimes seem to have the upper hand, [art] is more necessary than ever, because beauty is always a source of joy," Pope Francis said during a visit with a Catholic art organization last year.

The burgeoning field of neuroaesthetics—which examines the biological basis for our emotional responses to art—supports this view. Research shows that engaging with art can activate the brain's reward system, releasing chemicals like dopamine, serotonin, and oxytocin. Aesthetic experiences, like museum visits, are also associated with decreased loneliness, improved mood, and stress reduction. Some neuroscientists have even compared viewing art to the feeling of romantic love.

And in the wake of the COVID-19 pandemic—which forced the Vatican Museums to close three times between 2020 and 2021—there's a growing global movement to expand access to the arts as a pathway to well-being.

A 2019 World Health Organization analysis of more than 3,000 studies revealed that artistic and cultural activities promote physical and psychological health, and the UN agency called on policymakers to strengthen public arts programming. In fall 2022, physicians at one of the largest hospitals in Brussels partnered with the city to launch a six-month pilot study examining the benefits of "museum prescriptions" as supplemental treatment for stress, burnout, and anxiety. It's the first investigation of its kind in Europe and could have ripple effects across the continent.

Pope Francis has also long advocated for more inclusive access to art. "[The Vatican Museums] must open their doors to people from all over the world, as an instrument of dialogue between cultures and religions, a tool for peace," he wrote in his 2015 publication *La Mia Idea di Arte*. Crea suggests that the Vatican Gardens—where plants from all over the world bloom and flourish—embody this philosophy.

"Everyone can find something beautiful, something moving," says Crea, who welcomes small groups of travelers to accompany him during his morning routine on select dates. "The Vatican Museums, in my opinion, should be visited because they give you an understanding of art and history regardless of your faith." ▯

Gulnaz Khan is a writer and editor covering the intersection of climate change, environment, and culture. Photographer **Alberto Bernasconi** is based in Milan.



"The real privilege is being able, every day, to walk through this, and each day learn something new," says Crea.


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WHAT'S NEW AND NOTEWORTHY AROUND THE WORLD

This month's picks range from King Charles III's coronation stone to Romania's favorite flower.

BY **RONAN O'CONNELL**



1

ANCIENT ARTIFACT

Royal Rock of Ages
For the past seven centuries, the Stone of Scone has been used for coronations in Britain, enclosed beneath the chair on which the new sovereign is crowned. Mystery shrouds the slab's origins, but legends trace it to ancient Rome or Palestine. Later it reputedly traveled to Egypt, Spain, and Ireland. The roughly 335-pound block just took a jaunt to London's Westminster Abbey for King Charles III's ceremony. When it's not in royal service, the stone sits on display in Edinburgh Castle.

2



FAVORED FLORA

RECENTLY NAMED NATIONAL FLOWER, THE PEONY BLOOMS IN SEVERAL VARIETIES ACROSS ROMANIA. THEY BRIGHTEN GREEN SPACES FROM THE STEPPE PEONY NATURE RESERVE TO THE BUCHAREST BOTANICAL GARDEN.



3

CURIOUS HISTORY

ARMENIANS IN SINGAPORE
Though the British founded the city-state, Armenian families created some of its earliest institutions. Among them: the celebrated Raffles Hotel and what's now the country's oldest newspaper. The updated Armenian Heritage Gallery Singapore (above) tells these lesser known stories.

4



GREAT TRAIL

Walkers and bikers are heading to a new path that will become the first to connect two U.S. national parks. The initial segment passes through Homestead, Florida, but the finished Biscayne-Everglades Greenway will make a 42-mile loop between coral reefs and alligator-dotted marshes.

PHOTOS (1-4): SANTIAGO ARRIBAS PEÑA, WITH PERMISSION OF HISTORIC ENVIRONMENT SCOTLAND; PUCS FONGABE, GETTY IMAGES/ISTOCKPHOTO; AGENCJA FOTOGRAFICZNA CARO/ALAMY STOCK PHOTO; CHRISTIAN MOORE, GETTY IMAGES

THEY'RE ALL OVER HER AT THE BALL. THEN SHE'S ON HER OWN.

PHOTOGRAPH BY **KARINE AIGNER**

THINGS HEAT UP each spring in the Sonoran Desert. As the cacti begin to bloom, thousands of cactus bees *(Diadasia rinconis)* emerge from the underground nests where they hatched and matured. The males exit first. The females come out later to find dozens of males awaiting them. No time is wasted with introductions. As soon as a female appears, a swarm of suitors descends upon her, jockeying for the prime position on her back. The writhing ball they form is a rarely seen spectacle of nature.

It's also the female's launch into parenthood. Unlike honeybees, which are social, cactus bees are solitary. After mating, the female flies off to parts unknown and spends time in a state of suspended animation known as diapause, which allows her to survive desert temperature extremes. But the next year in spring, when cacti bloom again, she'll burrow in the dirt to form nests. Fashioning a separate cubby for each egg, she will leave a paste made from pollen and nectar for her future progeny to eat. After laying her eggs and sealing the nest entrances, the female will die.

About 15 days later, when the late mother's offspring leave the nests as adults, the cycle starts anew, filling the desert with an expectant buzz. —ANNIE ROTH



HABITAT/RANGE

Cactus bees are found in deserts in the southwestern United States and in parts of Mexico where cacti are plentiful. The best time to see them is in spring, when prickly pears and chollas are in bloom.

OTHER FACTS

Photojournalist and *National Geographic* contributor Karine Aigner captured this bee ball in 2021 in South Texas. The image won her the 2022 Wildlife Photographer of the Year award given by the Natural History Museum in London.

Cactus bees collect pollen and spread it among plants they visit, but they don't make honey. Honeybees that drink nectar from the blooms of cacti make real "cactus honey."



NGM MAPS

Once on These Islands

CALIFORNIA'S CHANNEL ISLANDS NATIONAL PARK TELLS A 13,000-YEAR-OLD STORY.

BY **MILES W. GRIFFIS**

RINGED BY AQUAMARINE waters, Santa Rosa Island is a folded landscape of canyons, mountains, and hanging sea cliffs. But there's more here than meets the eye. Archaeological intrigue lingers on this temperate isle, the second largest in California's Channel Islands National Park.

While digging in the island's Arlington Canyon in 1959, archaeologist Phil Orr discovered two femurs that he suspected dated back thousands of years to the late Pleistocene epoch. That alone was not unique.

Orr conducted fieldwork on windswept Santa Rosa for more than two decades. During his many expeditions, he excavated entire villages of the Chumash people and numerous graves and middens, as well as the large bones of pygmy mammoths, which roamed the area around 12,000 years ago.

But nearly 40 years after Orr's discovery, John R. Johnson, Orr's successor at the Santa Barbara Museum of Natural History, and park archaeologist Don Morris determined that the femurs were more than 13,000 years old—making them some of the oldest known human remains in North America.

The Arlington Springs man, as the bones were called, supports the theory of a coastal migration by the earliest people from northeast Asia to the Americas paddling the "kelp highway" of the northwestern Pacific Rim. The discovery has led to more questions than answers, but Chumash scientists and oral histories help illuminate its meaning.

Julie Tumamait-Stenslie, the former chair of the Barbareño/Ventureño Band of Mission Indians composed of Chumash families from Santa Barbara and Ventura Counties, believes there's likely ancestry older than the Arlington Springs man on the islands, but it just hasn't been discovered yet. These relatives were skilled boatmakers, astronomers, and fishers who built thriving villages, overseen by both male and female leaders in a matrilineal society. Their pictographs can be seen today at places like Chumash Painted Cave State Historic Park near Santa Barbara.

On Santa Rosa (Wima, to the Chumash), there are at least eight known Chumash village archaeological sites. Many others were likely submerged when sea levels rose and divided the mega-island of Santarosae into the four northern Channel Islands. Excavated middens on the island have revealed stone projectile points, fish barbs, beads, and animal remains.

In other middens on nearby Santa Cruz Island, anthropologist Brian Holguin, who is Samala Chumash, says he's excavated seagrass hundreds of years old that is so well preserved by the conditions on the islands that it's still green.

At Channel Islands National Park, which was established in 1980, Tumamait-Stenslie educates visitors around summer campfires about Chumash culture. She often tells the Rainbow Bridge story, in which the ancestors were created on Santa Cruz Island (Limuw) before they crossed to the mainland on a multicolored overpass.

Now members of the Chumash community cross the Santa Barbara Channel every September, from the mainland to Santa Cruz Island's Scorpion Beach, in *tomols,* large traditional canoes built of hardwood and sealed with tar.

"It shows the important transportation link between the mainland and the islands, and it really helps preserve paddling in maritime Native cultures today," says Barbara Tejada, acting director of the Chumash Indian Museum in Thousand Oaks.

Disney+

Explore protected wildlands in season two of *America's National Parks,* premiering on National Geographic June 5 and on Disney+ June 7.



Santa Rosa, with its white sand beaches and miles of uncrowded trails, is one of five isles that compose Channel Islands National Park, off the California coast. The park protects one of the oldest known human settlements in North America.

Tumamait-Stenslie suggests viewing Santa Cruz Island as a natural history museum to understand the Chumash's relationship with the landscape and the sea. She often thinks of her forebears' resourcefulness—how, for example, they used seagrass, willows, and animal parts to construct dome huts for shelter: "[Imagine] walking through the doorway of your home that happened to be the jaw of a great blue whale." ▯

Miles W. Griffis is based in Southern California. He often camps and bird-watches on the Channel Islands.





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FEATURES



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SOFT MUD GIVES WAY TO BLACK ROCK, AND THEN WE TIP INTO THE BLACK HOLE. AT 250 FEET, THE CYLINDER OPENS UP INTO AN ABYSS SO LARGE THAT THE BEAM OF OUR LAMPS CANNOT LOCATE A WALL.

PHOTO: LAURENT BALLESTA



WILD

A JOURNEY INTO NEW MEXICO'S GILA WILDERNESS REVEALS THE ENDURING LEGACY OF PRESERVING OUR NATURAL LANDS—AND RAISES COMPLEX QUESTIONS ABOUT WHAT IT MEANS FOR A PLACE TO BE, TRULY, WILD.



Hidden canyons and high meadows distinguish the Gila Wilderness, land once inhabited by the Apache. In 1924, the Forest Service designated it as the world's first "wilderness area," where people could visit but must leave no permanent mark.

WEST

BY PETER GWIN

PHOTOGRAPHS BY KATIE ORLINSKY



Biologists from the U.S. Fish and Wildlife Service prepare to administer vaccines to a Mexican wolf at a facility near the Gila Wilderness. The species is being reintroduced to the region after it was nearly driven to extinction.



W

WE WERE CAMPED IN A GROVE of ponderosa pines and had built a fire from the deadfall. The horses had been tied up for the night, the dinner plates scraped; and we sat on our saddle blankets, hunched against the November chill, waiting for the coffeepot to boil. Shadows cast by the fire rose and fell on the enormous tree trunks, like images on a drive-in movie screen.

Joe, an Apache guide who like his ancestors had ridden this country and knew its secrets, was telling the story of a wolf. It had been killed not far from here. He spoke in a slow, deliberate cadence that gave each of his words a certain weight, like the river stones we'd carried to build the fire ring. And then, a wolf howled. The cry rose out of the night, as if the telling of the story had conjured it.

The sound was startling because for the past few days, we'd heard almost nothing. As we rode deeper into this landscape, it seemed that the forests and canyons swallowed nearly all sound, reducing our world to the river, the wind, the horses, our voices. Sometimes as we rode over the grassy bluffs and down the switchbacks into the gorges, I felt like I'd gone deaf or had started dreaming. But the howl triggered something, and suddenly, I was aware of every sound—the hiss of the fire, the murmur of the horses, my own breathing.

Instinctively, we looked up, trying to glimpse the animal on the ridgeline. But all we could see were the silhouettes of trees, framed against a pale spray of stars.

We waited for the wolf to howl again, or another wolf to answer. But it was silent.

The story Joe was telling goes like this: In 1909, a young forester was surveying land in the southwestern corner of the New Mexico Territory, not far from where we were camped. He was eating lunch on a rock rim with some of his men. They spied a wolf and her pups in the canyon, grabbed their rifles, and shot them. Wolves, then, were considered vermin, the destroyer of cattle, elk, and deer, and eliminating them, and all predators, would create a better environment.

Near the end of his life, the forester wrote: "We reached the old wolf in time to watch a fierce green fire dying in her eyes ... I was young then, and full of trigger itch; I thought that because fewer wolves meant more deer, that no wolves would mean hunters' paradise. But after seeing the green fire die, I sensed that neither the wolf nor the mountain agreed with such a view."

It's possible to trace that dying wolf to the creation of the place where we were camped, the Gila Wilderness. That young forester was Aldo Leopold, part of a vanguard of rangers looking to employ the latest science to manage millions of acres of federal land.

His encounter with the wolf and other observations led Leopold in 1922 to write a letter calling for a new land designation. By then, the government had recognized two kinds of public lands:



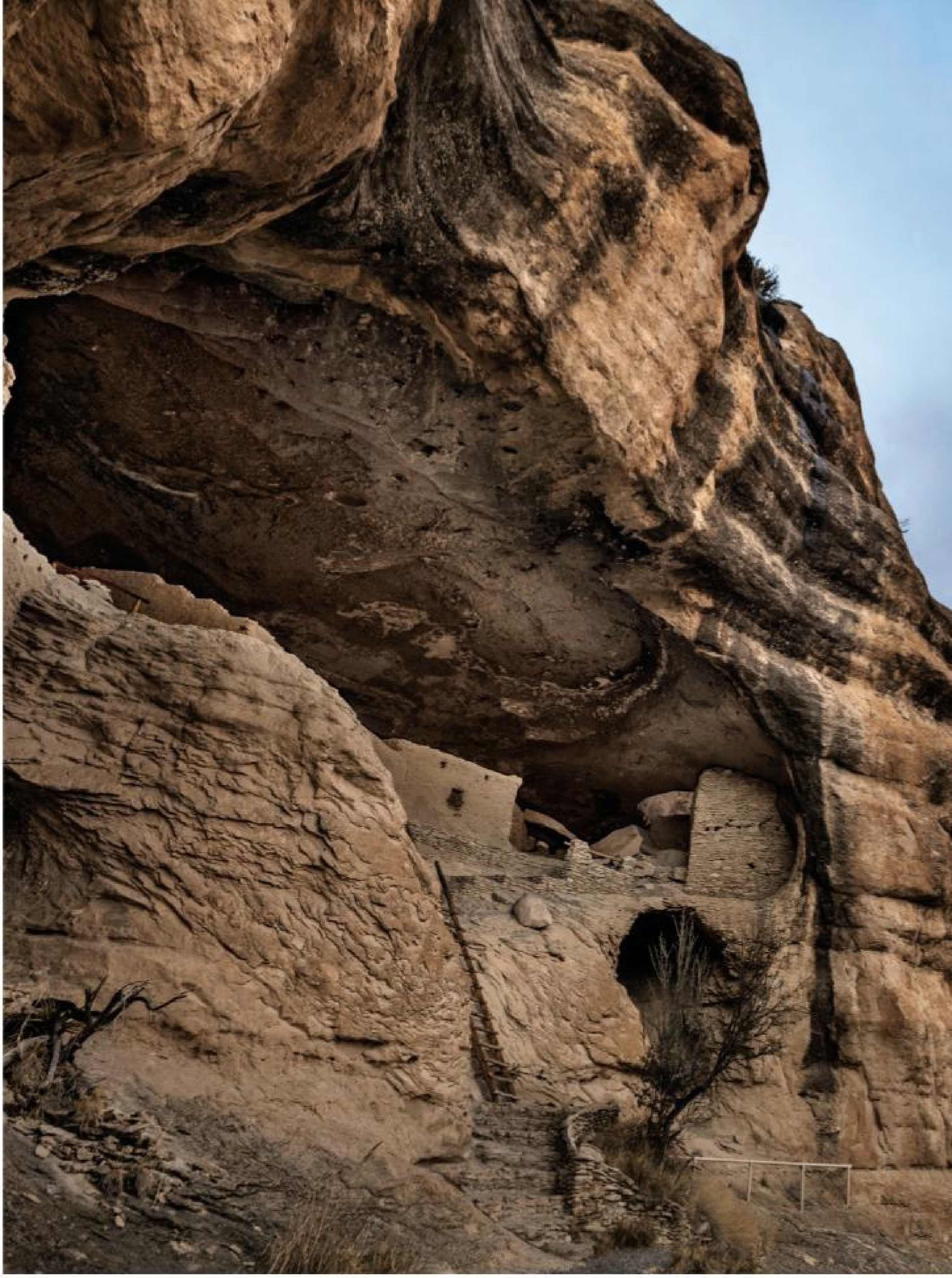
Laney Lopez, 11, wears the blood of her first elk kill, daubed on her cheeks by her dad. Her hunt, just outside the wilderness area, was part of a program to bring young people into the sport. “Hunting is our family tradition,” she says. “It feels good to help put meat in our freezer.”





Backcountry guide Joe Saenz leads a horse laden with supplies for a 10-day trip exploring the headwaters of the Gila River. Saenz descends from a band of Chiricahua Apache who lived for months at a time in these canyons. “When I’m here,” he says, “I’m in my home.”

Caves fortified by 13th-century builders from the Mogollon culture are now preserved as the Gila Cliff Dwellings National Monument. Similar ruins are found throughout the region, attesting to the presence of humans here for thousands of years.





The National Geographic Society, committed to illuminating and protecting the wonder of our world, has funded Explorer Katie Orlinsky's storytelling around North America since 2020.

ILLUSTRATION BY JOE MCKENDRY

National parks were to be preserved for recreational use and could be improved with roads, lodges, and other amenities, while national forests were to be managed for their resources, including timber, minerals, grazing, and game. But there should be something else, Leopold argued, a place left unaltered by humans. He identified 1,200 square miles at the center of the sprawling Gila National Forest (pronounced HEE-luh), which contained the headwaters of the Gila River, and in 1924, the Forest Service designated it as the world's first wilderness area.

My introduction to the Gila came one summer when I was a kid, staying with my grandparents in Colorado. News broke that a convict had escaped from prison. A neighboring rancher speculated the man would head south for the Gila Wilderness. "That's Apache land, where Geronimo was born," he told me. He described it as hard country, an endless labyrinth of mountain ranges and canyons, and home to monstrously large mountain lions. "If he's in the Gila, they'll never find him."

"Wilderness" is a slippery term. It can refer to almost any environment: jungle, swamp, icebound tundra, open ocean. Often it's synonymous with "wasteland," especially with regard to deserts, but it can just as easily refer to a forest bursting with life.



Politicians dread being "in the wilderness"—it means you've lost power—while religious figures tend to seek it out. It's where God spoke to Moses; where Jesus went to fast and pray; where the Buddha is said to have found "awakening"; and it's where Muhammad's parents sent him as an infant because it would be healthier than growing up in the city.

One dictionary defines "wilderness" as "uncultivated, uninhabited, and inhospitable," but the Gila is none of those things. Leopold proposed his own definition: "I mean a continuous stretch of country preserved in its natural state, open to lawful hunting and fishing, big enough to absorb a two weeks' pack trip and kept devoid of roads, artificial trails, cottages, or other works of man."

As COVID swept the planet in 2020, I thought a lot about wilderness. We'd all become prisoners of our cities, and some of us were fleeing civilization to return to our original home, the wilderness. I remembered the escaped convict. Did he make it to the Gila? Was he eaten by a mountain lion? Or had he somehow survived and was a grizzled hermit living out his days in a place without live updates on how soon the world would end.

And that's how I found my way to Joe Saenz, who leads trips into the Gila backcountry. I called him and told him I wanted to see the place that had captured my imagination as a child and given rise to the modern notion of wilderness. There was a pause on the phone. Finally, in his careful, considered manner, he answered. It was late in the season, but we might squeeze in one last trip in mid-November, ahead of the snows that would blanket the mountain passes.

WITH AIR TRAVEL near a standstill, I drove the 2,100 miles from my home near Washington, D.C., to New Mexico. I traveled through the heart of the country, crossing the Blue Ridge Mountains, the Mississippi River, and the Texas Panhandle. The route offered stark reminders of how radically humans change landscapes. I traversed miles of furrowed cropland and passed soaring wind turbines. I encountered bobbing pump jacks and flaring gas towers and feedlots so large that I could smell them long before I saw them. The Great Plains gave way to the Chihuahuan Desert, and the desert gave way to the Black Range. And there I left the freeway and climbed over the Continental Divide, following the serpentine road that led into the Gila.

I met Joe at dawn saddling his horses near a main trailhead on the southern edge of the wilderness. He wore turquoise earrings and a black cowboy hat with an eagle feather. The only hints he was in his 60s were his leathery hands and

the flecks of silver in his tightly braided hair.

Two colleagues from *National Geographic* and I planned to be gone for 10 days and cover 70 miles or so, exploring the main forks of the Gila River. Joe had said the horses could carry only so much weight on the steep terrain and to bring just the basics. We'd sleep on our saddle pads, out in the open, and he could string up a tarp if it snowed or rained. He'd packed food, a bow saw, a first aid kit, and a rifle.

Once the horses were saddled and the gear stowed, Joe asked if he could perform an Apache blessing. He daubed yellow cattail pollen on our foreheads, shoulders, hands, knees, and feet, and then sprinkled the pollen in the four cardinal directions, chanting a few Apache words. "I'm asking to pass through the land safely," he said. We mounted the horses and filed out of the corral, following the trail into a thicket of high willows.

We hadn't been riding for more than 10 minutes when we passed the Gila Cliff Dwellings National Monument, which is overseen by the National Park Service and sits just outside the wilderness area. I'd visited the previous afternoon and explored the maze of caverns modified with stacked-stone walls. An enthusiastic ranger in an immaculate Smokey Bear hat explained that people had been living in this region for thousands of years. Caves all along the Gila River bore ceramics, stone tools, and food caches, but these, overlooking a narrow canyon, were the biggest and most elaborately fortified. They'd been inhabited in the late 1200s by a culture known to academia as the Mogollon, but a century later, the people had vanished.

About a mile up the trail, we came to a wooden sign emblazoned GILA WILDERNESS. Beyond this point, the Forest Service forbids the use of mechanized vehicles, as well as bicycles and wagons, though hunting and fishing are allowed.

The trail crisscrossed the shallow river, and a golden fall sun filtered through the tall trees and glittered on the fast-moving current. After a couple of miles we saw no one else.



Jill Wick, a biologist with the New Mexico Department of Game & Fish, inspects a stream stocked with young Gila trout to restore the species. The population has declined because of many factors, including non-native trout introduced to boost fishing.



As we rode, I mentioned to Joe it seemed ironic that the government celebrated a place where people had lived for thousands of years as a paradigm of wilderness. He laughed. "The Gila is full of contradictions like that."

He was irked that the Park Service focused so much attention on the ancient cultures. The Mogollon, he said, were just passing through. The people who'd come to understand this land—and were still attached to it—were the Apache. Joe strongly believed they'd been here much longer than the 600 years or so acknowledged by scholars. Part of why he leads these trips, he said, is to help outsiders see the Gila through the eyes of his people. There wasn't a specific word for "wilderness" in the Apache language he speaks, rather just a word for land: *benah*. The idea that humans were somehow separate from nature didn't make sense to a people who regarded the animals as their relatives.

Our route would mostly follow old Apache trails, and it would take us on a tour of what Joe said was the northern stronghold. One reason settlers didn't turn this region into farms and mines is that the Apache fiercely defended it. "It's wild today because of the Apache," Joe said.

I asked him whether it was true Geronimo was born here. Pointing over the mountains to our east, he said, "In a canyon, just over there." Geronimo was a controversial figure for some Apache, Joe said. For all his fame as a great warrior, he'd surrendered and led his followers into captivity, and they'd lived out their days far from this land, in Fort Sill, Oklahoma. Joe said his own family was part of a band that refused to surrender and had dispersed across the Mexican border into the Sierra Madre, the southern stronghold.

As such, Joe explained, he and others of similar lineage didn't belong to a tribe recognized by the government. But he wasn't bothered that he didn't have a plot of land in Fort Sill or receive money from a reservation casino. "I have Apache culture and horses," he said. Sweeping his hand over the land, he added, "And I have all of this."

IT WAS SPECTACULAR TERRAIN, sculpted by a supervolcano 40 million years ago, but as the days progressed, we came to understand that it wouldn't easily reveal itself. We rode along dry canyon rims bristling with cacti, including spiny star, cane cholla, and scarlet hedgehog. Then we'd descend trails so steep I had to stand in the stirrups and lie back on my horse's rump as he picked his way down to the river. There, we'd enter a hidden world of ocher rock walls and deep clear pools and tumbling rapids. The horses would drink, and we'd lazily follow the river. Each bend revealed a new collection of hoodoos—rock pinnacles eroded out of the cliffs—in an array of majestic shapes. I saw spires and minarets, sphinxes and gargoyles. After Joe said that families would entomb their dead in the cliffs, the hoodoos began to resemble solemn Apache faces staring down at us.

When a canyon became too narrow, we'd climb out and emerge in a meadow of rabbit's-foot grass, a stand of quaking aspen, or a copse of charred husks left by wildfire. We'd ride across the mesas, the sun hot on our backs, dip into the cool shadows of a forest, and then drop back down into another secret realm.

As we rode, Joe described how the Apache had sustained themselves on the land, how bands moved regularly to hunt game and harvest wild crops, how they cached supplies among the caves for emergencies. He pointed out edible plants: prickly pears, banana yuccas, fiddlehead ferns, and wild raspberries. He noted agave, which was served at girls' puberty ceremonies; sagebrush, which could be brewed to make a healing tea; and sumac berries, which contained an oil used to cure game.

But the land wasn't without its reminders of more recent history. We found tangles of barbed wire; a miner's drill bit; a bow saw, which Joe added to his kit; ceramic insulators used for a firefighting telephone system; and the rusting hulk of a metal cistern that Joe said was installed to provide water for elk. He explained that after the

native elk subspecies had been hunted to extinction, Rocky Mountain elk were imported. To help these replacements contend with such dry conditions, cisterns were brought in to catch rain. Over the years, the watering stations had been abandoned. Now most, like this one, didn't function.

It was a strange object to find in a place that was supposed to be "devoid of... works of man." I told Joe that I'd always assumed that wilderness meant you drew a line around an area and left it alone. No, he said, the Forest Service was constantly trying to control the land and its creatures. And it wasn't just government that had strong views about what wilderness meant; hunters, ranchers, hikers, environmentalists, even people who'd never been here had their own ideas about what belonged in the Gila and what didn't.

He mentioned how rainbow and brown trout had been introduced to the river to please anglers, but for the past 50 years biologists had been trying to kill them—going so far as to poison long stretches of the river—all in the name of saving the native Gila trout.

But if the government's idea of wilderness was putting the land back the way it had been, Joe wondered, then why not put the Apache back? If the elk and Gila trout were intrinsic to the landscape, what about the humans who'd lived with them for centuries? Why not let the Apache—whose culture was based on living in concert with nature—help manage the land?

The last morning before we left the wilderness, we awoke covered in feathery snowflakes. We were out of food and coffee, and our clothes were grimed with dirt, sweat, and campfire smoke, but Joe wanted us to see one last place, a spot he called the Gila Grand Canyon.

After two hours of hard riding, we tied up the horses and sat on a cliff overlooking a broad canyon, facing a colossal wall of hoodoos that looked like the British Houses of Parliament. Far below us, shadows of clouds glided across the valley floor. I watched a hawk ride a thermal until the currents carried it out of sight. The silence was hypnotic, and my mind seemed to settle into a perfect equilibrium. We sat quietly, for a long while. From here, it looked like the wilderness stretched forever.

ONE DICTIONARY DEFINES 'WILDERNESS' AS 'UNCULTIVATED, UNINHABITED, AND INHOSPITABLE,' BUT THE GILA IS NONE OF THOSE THINGS.

I RETURNED TO THE GILA several times. I wanted to explore more of its mesmerizing landscape, but I also wanted to understand what "wilderness" here actually meant.

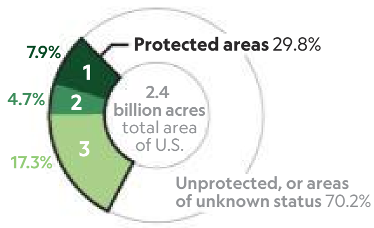
Usually, I rented a place in Gila Hot Springs, a tiny community almost surrounded by the wilderness area. It's a hodgepodge of wooden cabins, adobe structures, prefab buildings, and trailer homes. The people who live here are an eclectic mix—biologists and backcountry

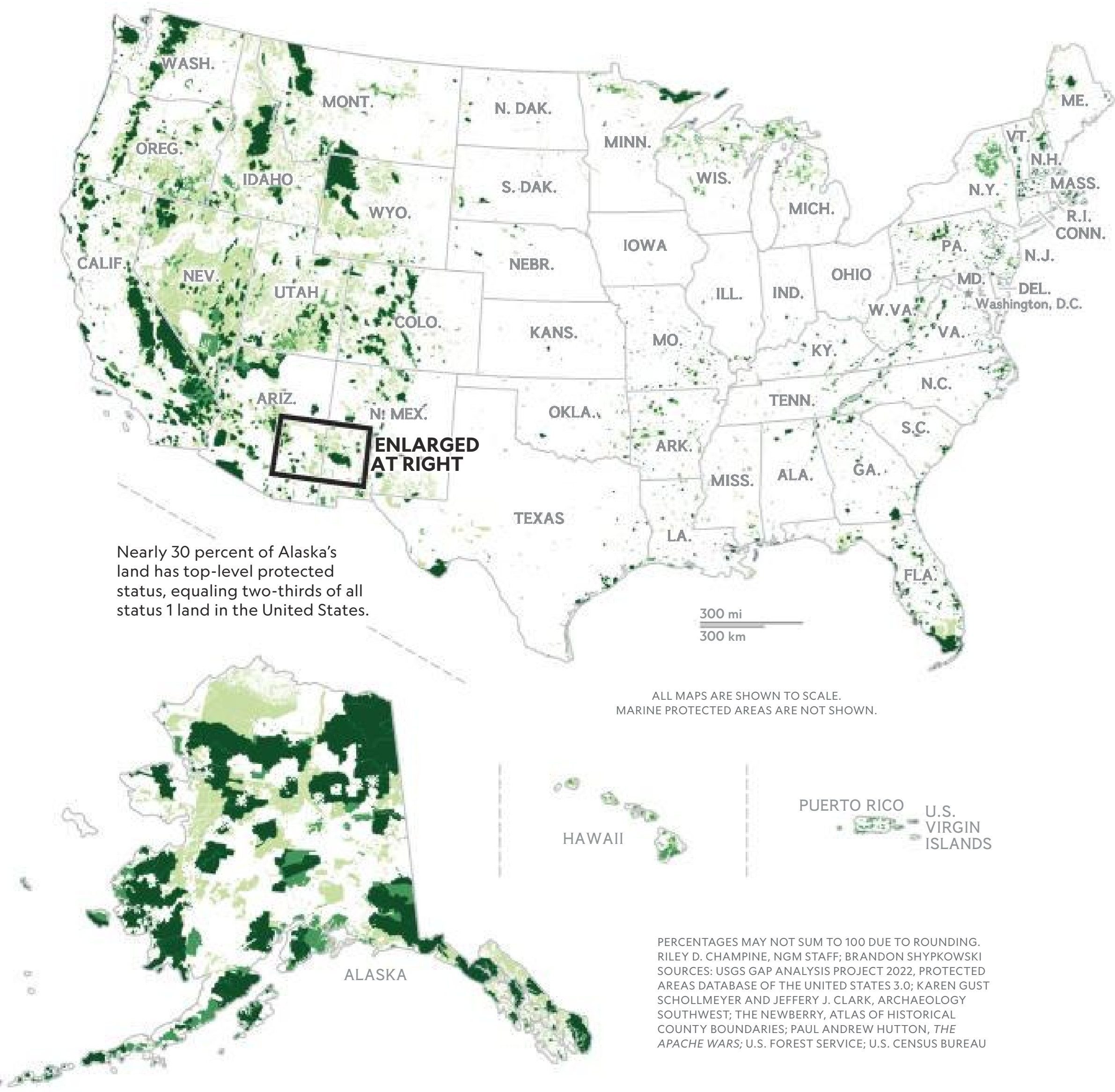
MANAGING THE WILD

Almost a third of all U.S. lands and waters are now protected areas, sheltering many of the country's remaining wild spaces. Over a century and a half, these natural landscapes have been set aside to prevent their conversion into other uses, such as urban development or agriculture. The goal: to preserve cultural use, recreation, and biodiversity.

The U.S. Geological Survey uses three rankings to assess protected areas, based on how they are managed:

1. Status 1 areas, including wilderness areas and many national parks, allow natural disturbances such as wildfires to occur.
2. Status 2 areas, including national wildlife refuges and conservation areas, suppress natural disturbances.
3. Status 3 areas, including national forests, have mixed uses and can permit activities such as logging, mining, or grazing.





Nearly 30 percent of Alaska's land has top-level protected status, equaling two-thirds of all status 1 land in the United States.

ALL MAPS ARE SHOWN TO SCALE.
MARINE PROTECTED AREAS ARE NOT SHOWN.

PERCENTAGES MAY NOT SUM TO 100 DUE TO ROUNDING.
RILEY D. CHAMPINE, NGM STAFF; BRANDON SHYPKOWSKI
SOURCES: USGS GAP ANALYSIS PROJECT 2022, PROTECTED AREAS DATABASE OF THE UNITED STATES 3.0; KAREN GUST SCHOLLMEYER AND JEFFERY J. CLARK, ARCHAEOLOGY SOUTHWEST; THE NEWBERRY, ATLAS OF HISTORICAL COUNTY BOUNDARIES; PAUL ANDREW HUTTON, *THE APACHE WARS*; U.S. FOREST SERVICE; U.S. CENSUS BUREAU



THE HEART OF

The southern slopes of the Colora
environment for cool, moist woo
region is home to the Gila Wilder
that in 1924 became the world's f
area. Although designated to re
the wilderness and other protect
been shaped by thousands of yea

TRACES OF PAST PEOPLES

The region has been inhabited for thou
years, with well-preserved archaeologi
indicating that farming began in the riv
reaches around the year 200. Different
distinctive building and pottery styles,
and mixed with others because of socia
pressures. Many Upper Gila farming set
were abandoned for unknown reasons



THE GILA

ado Plateau provide an ideal
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APACHE HOLDOUTS

The Apache, a mainly nomadic people in loosely affiliated bands, may have migrated to the Southwest in the 1400s or 1500s. Until the 1880s, the Chiricahua Apache lived around the headwaters of the Gila and fiercely resisted Mexican and later U.S. control. Many were killed in battle or taken by the U.S. Army as prisoners of war to Florida and Oklahoma.





Rancher and backcountry outfitter Becky Campbell lives in the home her father built on the edge of the wilderness. She taught herself to call elk and track mountain lions but recently stopped guiding hunts. “There just aren’t that many elk anymore,” she says.

THE EXTRAORDINARY HUMAN ABILITY TO ALTER AN ECOSYSTEM COMPLICATES THINGS.

guides, ex-hippies and ranchers, military veterans and hard-core vegans. Some moved here to raise their kids close to nature, some to escape the city, others to deal with the loss of a loved one. They were all devoted to the land in their own way and eager to show it to me.

Zack Crockett led me on horseback to isolated stone ruins. I scouted for spotted owls and inspected beaver dams with his wife, Jamie. Becky Campbell let me tag along as she packed her horses with gear and provisions for the season’s last elk hunt, and Dean Bruemmer showed me where scalding water seeps out of the rocks, giving Gila Hot Springs its name.

Whenever I asked what they thought wilderness was, they generally defaulted to describing what they saw as threats to it. Some feared hunters were ruining it; others worried that banning hunters would harm it. They worried about wildfires and floods and the loss of the snowpack. They talked about the destruction caused by feral cattle, intruding armies of American bullfrogs, and numerous invasive

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ncluding tamarisk trees from Asia.
on long solo rambles. I caught glimpses eared squirrels, javelinas, and a young ar gobbling juniper berries. I found a ed elk skeleton, its chalk-white verte- perfect line. I slept on the porch so isten to the night and often awoke to ng wild apples just a few feet away. One , a raspy scream jarred me from sleep. l out to be a female mountain lion in opped sleeping on the porch.

nce the rancher had told me about the untain lions in the Gila, the creatures ed my imagination as the untamable ment of wilderness. I'd read how the ts could flow in and out of canyons r, leap 15 feet straight up, and snap the their prey with a single bite. I'd seen f hunters hugging their kills, burly d queens, some nearly eight feet long, huddered at their size.

I heard about a retired conservation who was in Gila Hot Springs to hunt n lions, I tracked him down. Nick Smith t, sinewy, 60-something man with a ay goatee and a friendly manner. I told ut my obsession, and he agreed to let him.

ck wasn't here to kill mountain lions. n hired by the New Mexico Department & Fish to tranquilize several of the ani- put satellite collars on them. Selfishly, d think about was the chance to touch ese creatures alive—stroke its warm fur, its dagger-like teeth, feel its heartbeat— getting mauled.

morning, Nick saddled two mules—he y were calmer than horses—and we his hounds into the wilderness. For s, we saw tracks, with their distinctive and large heel pad, and examined scat ng bones and fur of small game, but we ught a glimpse of a lion. It had begun to we were looking for ghosts. Oh, they're nearby, probably watching us, Nick said. But they remained invisible.

On the fourth morning, Nick spotted a shallow impression. "Looks like a female," he said, judging by the print's small size. The dogs picked up the scent and raced ahead. We followed them on a tortuous route, up an impossibly steep ridge and then down into dense thickets of alligator juniper, mountain mahogany, and bear grass. Nick spurred his mule, and we bulled our way through the underbrush, branches ripping at our clothes.

Finally, the dogs treed the mountain lion. Chile, Nick's best tracker, had sniffed his way to the base of a tall cottonwood growing in the lee of an outcrop. While the frenzied dogs barked and howled, Nick got off his mule and circled the tree, staring up into its canopy. But the cat was gone. "Must've climbed to the top of the tree and jumped to the rocks," he said.

Back at his cabin, I asked Nick about the mountain lion study. He hadn't caught one yet this season, but when he did, he'd record the sex, age, size, and health. The satellite collar would reveal the boundary of its territory. All this was vital data for equations that state biologists were constantly balancing. Too many mountain lions was bad for the bighorn sheep population. Too few was bad for the predator-prey balance and also for hunters who paid outfitters, which in turn fed into fragile rural economies.

Trying to maintain a healthy mountain lion population seemed like a worthy goal, but something troubled me about the idea of managing these wild creatures. It felt like manipulating nature, picking winners and losers. It reminded me of what Joe had said about killing some trout to save others. So I reached out to David Propst, one of the biologists who'd overseen the work to preserve the Gila trout.

Restoring wilderness is problematic, he said. "Nature constantly evolves, so you're arbitrarily choosing an ecological moment in time to return it to." But, he said, the extraordinary human ability to alter an ecosystem complicates things. If people hadn't degraded the fish habitat by logging and overgrazing and hadn't dumped rainbows and browns into the river, the Gila trout would've likely continued to flourish.

Now, without human intervention, this fish—which has a lineage tracing back more than a million years and bears the golds and reds of a New Mexico sunset—would disappear forever. Think about what we're losing, David said. The Gila trout had descended from the Pacific salmon, which somehow had made its way from the Gulf of California up into these mountains. It possessed a unique combination of genes that allowed it to survive wildfires, droughts, and floods, and it could hold traits scientists had yet to discover. "It's part of our natural heritage," David said. "By neglect or intent, why would you want to get rid of part of our natural heritage?"

SEVERAL MONTHS LATER I was hiking up a steep ridgeline with Nic Riso, who had two wolf pups in his backpack. A fire had thinned out the young trees and underbrush, leaving only the largest ponderosa pines. It was late April, and green shoots were poking through the sooty ground. The pups squeaked, and Nic, a biologist with New Mexico Game & Fish, gently took off the pack to check on them.

He was part of a team of federal, state, and local officials that is embarked on one of the most ambitious biological restoration projects in the Southwest—bringing back the creatures that the young Aldo Leopold had been directed to exterminate.

That morning, before dawn, I'd met Susan Dicks, a veterinarian from the U.S. Fish and Wildlife Service, near Socorro, New Mexico. She and a colleague had gone into an enclosure containing a male Mexican wolf, a female, and a litter of week-old pups. The female bolted from the den, and Susan removed two pups,



The 649-mile Gila River begins in southwestern New Mexico and flows to Yuma, Arizona. In 1922, when a forest ranger named Aldo Leopold proposed the first wilderness area, he suggested it encompass the Gila's headwaters, ensuring they would remain dam free.



each a cuddly ball of dark brown fur about the size of my fist. She brought them into the facility's office. Their eyes wouldn't open for another week or so, and they whimpered softly as she weighed them, listened to their hearts, and checked for birth defects.

Sadly, even after Leopold had his awakening about the importance of wolves, people didn't stop killing them. By the 1970s, the Mexican wolf, a subspecies of the gray wolf, had disappeared from the wild in the United States. In 1977, under a joint U.S.-Mexico agreement, U.S. Fish and Wildlife hired a Texas trapper to venture across the border into the Sierra Madre to see if he could capture wolves that could be used to start a breeding program. The trapper eventually came back with five wild wolves, which were combined with two wolves raised in captivity. These pups were recorded as the 2,709th and 2,710th wolves descended from those original seven.

The pups were packed in a pet carrier, and we drove five hours to the edge of the Gila Wilderness. There, we met another team that had located a breeding pair of wild wolves, which had a 10-day-old litter. The plan was to add two captive-bred pups to that den. This difficult and somewhat risky process was necessary to ensure the pups learned how to survive in the wild and to add a healthy mix of genes to this wild group.

Susan gave the pups milk and carefully wrapped them in a towel before placing them in Nic's backpack.

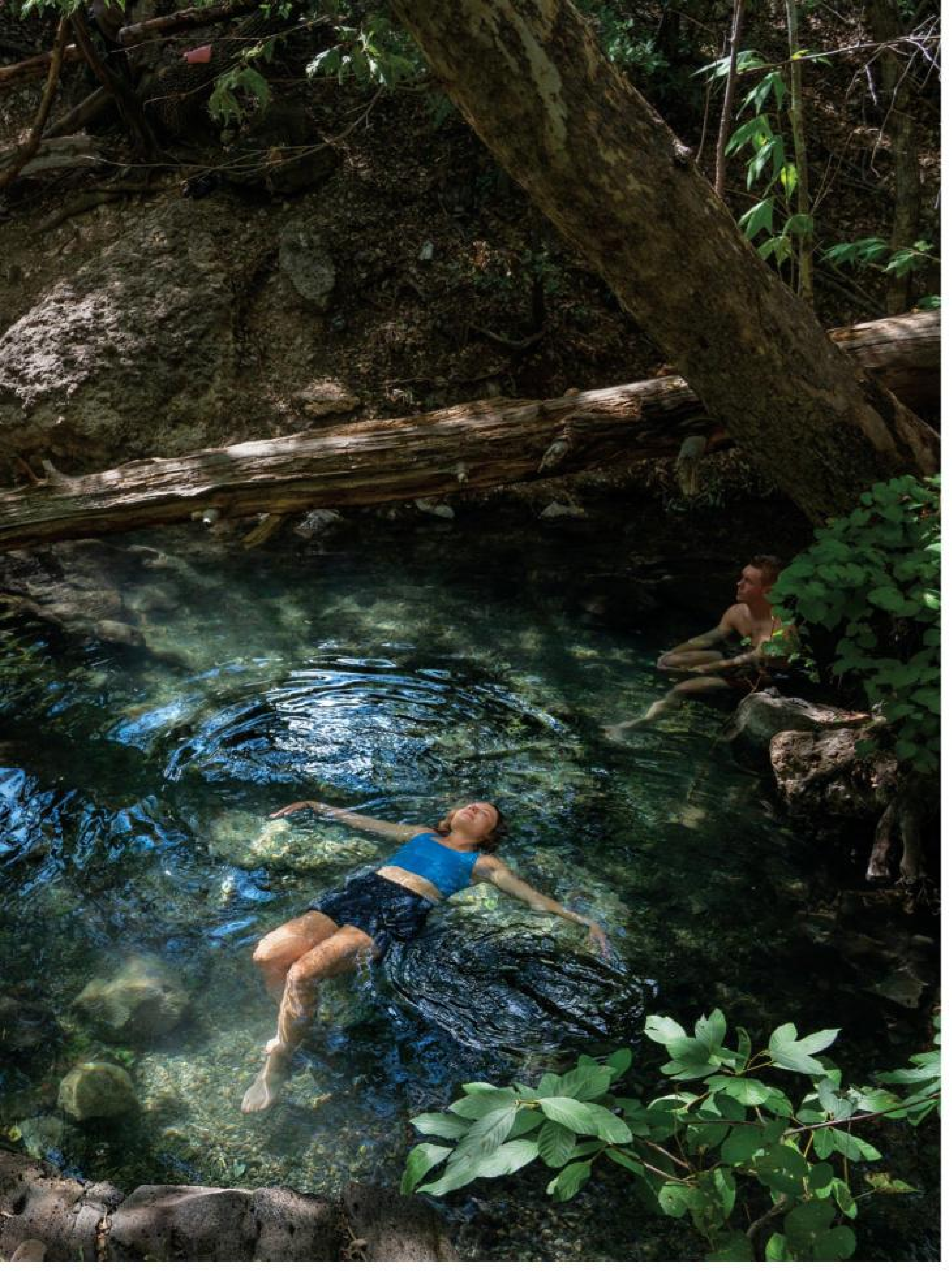
As we hiked, I saw elk droppings scattered everywhere, and Nic found an antler. "Plenty of prey here," he said. "And look!" He motioned to the cascade of yawning mountain valleys stretching to the horizon. "Wolves always seem to build their dens in a place with a million-dollar view."

We reached the den—a hollowed-out area beneath a large stump—after about an hour. The mother had fled when the first team approached to prepare for the new pups' arrival.



Wearing surgical gloves, the biologists gently removed the wild pups, checked their health, and recorded their sex and weight. Nic explained that mother wolves didn't count their offspring but would be keenly aware of their scent. The key was to get all of them to smell the same. So Nic and another biologist rubbed the pups' genitals with a damp cotton ball to make them urinate. Soon the pups had peed all over each other and were placed in the den.

As we headed out, I asked Nic how he got interested in wildlife science. He said he'd had a professor in college who'd told him about a pioneering biologist, a guy named Aldo Leopold.



Elena Lancioni pauses from hiking along the Middle Fork of the Gila River to float in a pool fed by thermal springs. In the century since Leopold proposed the idea of a wilderness area, the government has designated 802 others, protecting more than 111 million acres.

LATE IN THE AFTERNOON I found the ruins, a small cave with a low stone wall guarding the entrance. It was far off the main trail, obscured behind a thick stand of Gambel oak. There was a small collection of stone tools: a glassy obsidian scraper and a basalt mortar and pestle.

It was my last night in the Gila, and I wanted to be alone in this ancient campsite made by people who lived when practically the whole world was wilderness. I listened for wolves but heard none. The only wolf I ever heard in the Gila was the one with Joe. He said it was a gift.

As darkness closed in and the temperature dropped, I burrowed into my sleeping bag. I thought about the pups—how that morning they awoke as little more than zoo animals, but that night went to sleep as wild wolves. They might not survive a year. But, however long they lived, they would get to be the thing that wolves had evolved for over a million years to be. I couldn't think of a better definition of wilderness. Behind those tiny eyelids, which had yet to open to the world, I was sure there burned a green fire. ▯

Editor at Large **Peter Gwin** wrote about tracking snow leopards in the July 2020 issue. **Katie Orlinsky'**s photographs of the Arctic's thawing permafrost appeared in the September 2019 issue.


WHAT
LIES
BENEATH


WHEN COULD THE NEXT VOLCANO
ERUPT OFF ITALY'S COAST?
SCIENTISTS ARE DIVING FOR CLUES.
STORY AND PHOTOGRAPHS BY LAURENT BALLESTA





HISSING AND SPITTING HYDROTHERMAL VENTS ON THE SEABED RELEASE SUPERHEATED GASES THAT CAN REACH NEARLY 300 DEGREES FAHRENHEIT. YET LIFE ENDURES.

LEFT

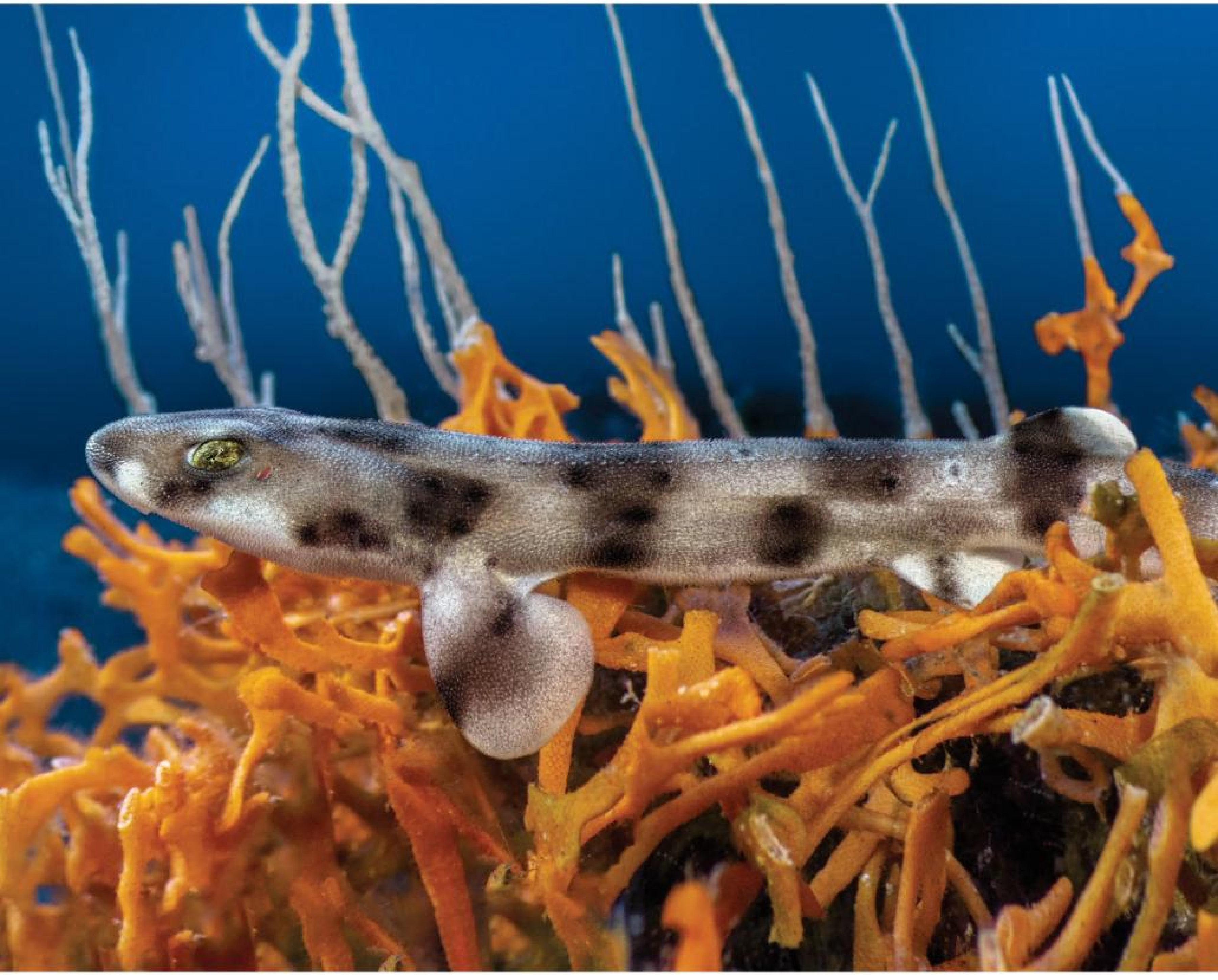
Where lava flows are the oldest, sea life is already recolonizing rock formations. New growth attracts the predator *Antiopella cristata,* an orange sea slug with white-tipped dorsal projections.

PREVIOUS PHOTO

In Panarea, one of Italy's Aeolian Islands, gases escaping from a magma chamber mix with the cold Mediterranean Sea, creating acidic bubbles known as "nature's Jacuzzi." The surrounding waters are so corrosive that ancient Roman mariners moored their ships here to cleanse barnacles from the hulls.

The night is beautiful and so is the sea

as our ship glides south along Italy's coast. I'm at the helm of the *Victoria IV* and could easily follow my course observing the sophisticated instruments on the bridge. But how could I resist relying instead on the ancestral navigation guide known as the Lighthouse of the Mediterranean? The small glowing light on the distant horizon is not the work of humans but rather fiery lava explosions from Stromboli, a volcanic island in the Aeolian archipelago north of Sicily. Though this flickering glow is barely perceptible from afar, it has persisted for thousands of years, and we're headed straight for it.



The Aeolian chain includes seven main islands and lies in the heart of the most active volcano system in the Mediterranean. Most of this activity occurs deep below the ocean floor. I've come here with Francesco Italiano, one of Italy's preeminent volcanologists, and Roberto Rinaldi, a renowned Italian filmmaker, to document, in part, the hissing and spitting of hydrothermal vents that form on the flanks of undersea volcanoes and spew out curtains of bubbles made of mineral-rich hot gases. Volcanic activity in this region remains a threat to millions of people who live along Italy's southern coastline, and Italiano and his colleagues want to find a way to better anticipate eruptions.

As a biologist, I want to see what kinds of marine species adapt and survive in places so hostile to life. It took two years to put together a research expedition, and we hope to unlock some secrets during our journey. The beauty of the world is important, but it is less fascinating than its mysteries.

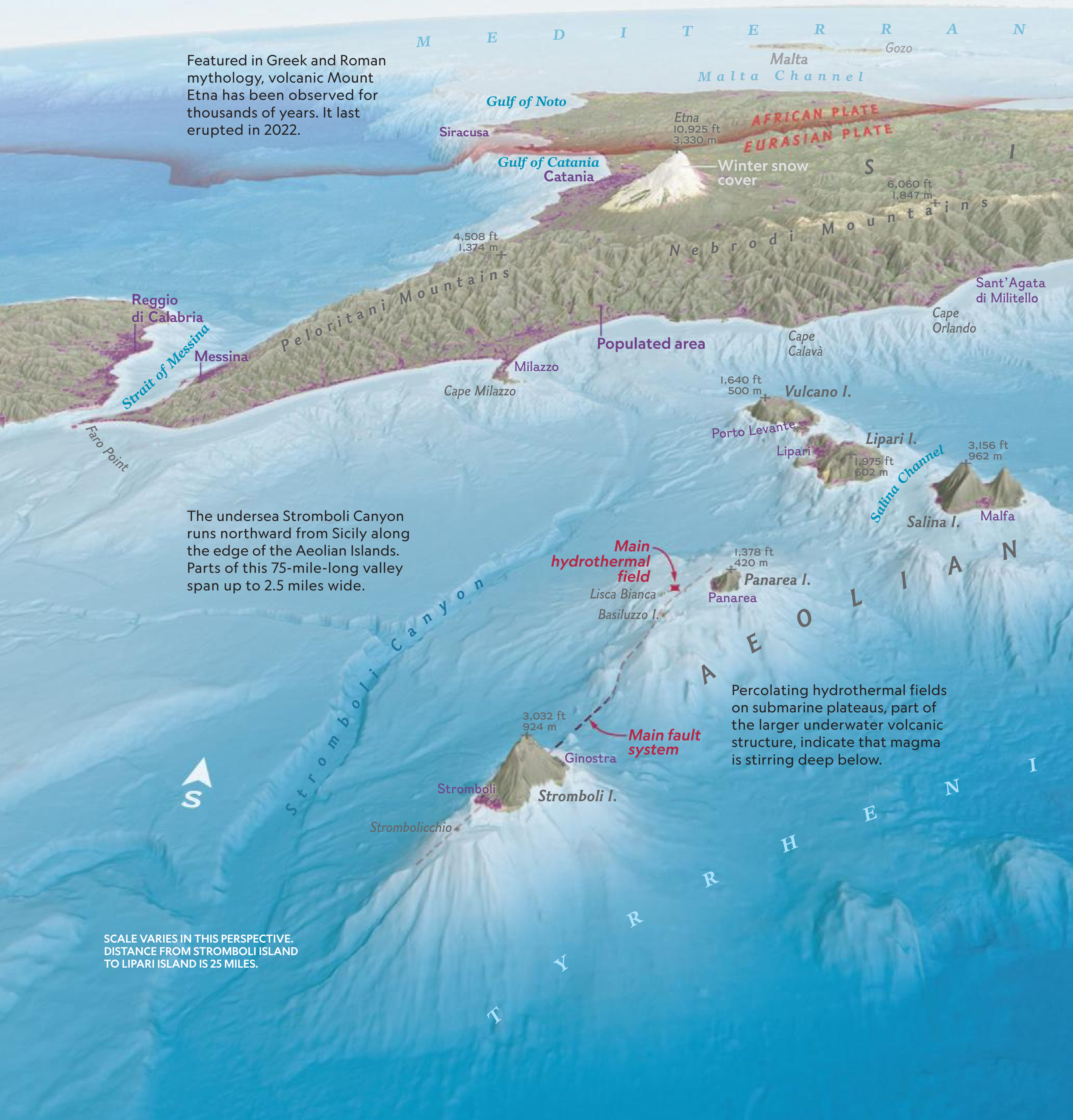
WE ANCHOR FIRST at Panarea, the smallest Aeolian island, and dive into shallow, acidic waters. Legend has it that ancient Romans moored here to clean barnacle shells off the hulls of their ships. Panarea is considered dormant, yet it hums with activity. Natural whirlpools give off a sulfur-like smell. Clouds of bubbles made of carbon dioxide and hydrogen sulfide rise to the surface with a steadiness that makes it feel



An active volcanic island, Stromboli continually sloughs off rock and sand that bury marine organisms below the surface. As soft corals half overtaken by a landslide recover, a young dogfish shark appears—a sign of life renewed.

BUBBLING FROM BELOW

Underneath Italy's Aeolian Islands in the Tyrrhenian Sea is a labyrinth of faults and fissures that regularly belch gas and lava. For millennia, people have lived among the fiery peaks and fizzing waters that make up this 90-mile arc born of volcanic activity. Today scientists are helping residents better manage the hazards of their unique landscape.



MATTHEW W. CHWASTYK, PATRICIA HEALY, AND LUCAS PETRIN, NGM STAFF
SOURCES: FRANCESCO ITALIANO, NATIONAL INSTITUTE OF GEOPHYSICS AND VOLCANOLOGY; USGS; NASA/JPL; ESA

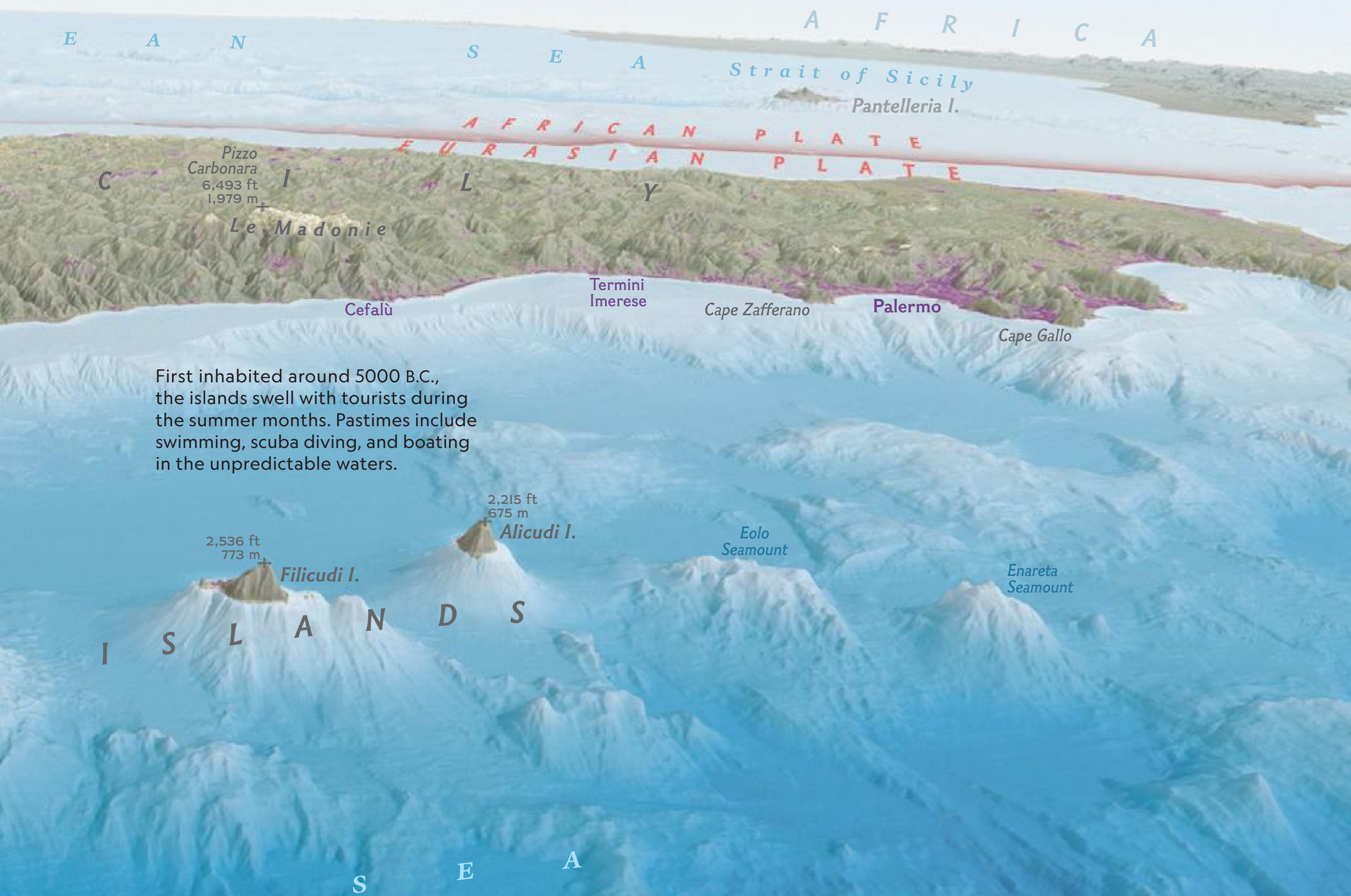
Edges of Eruption

Volcanoes form near the subduction zone where the African tectonic plate dives beneath the Eurasian one. Scientists study the converging plates to better predict eruptions and to increase preparedness for the populations that call the region home.

Tectonic plate boundaries

Subduction zone — Other

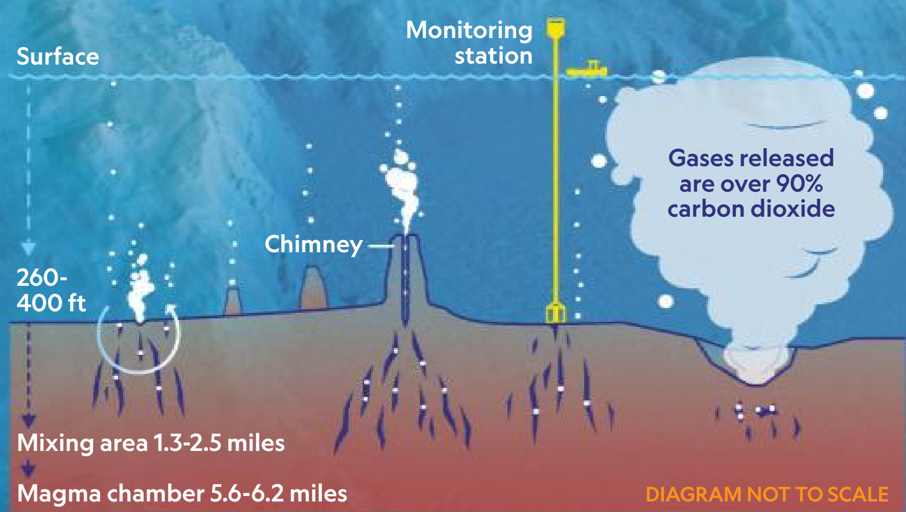




First inhabited around 5000 B.C., the islands swell with tourists during the summer months. Pastimes include swimming, scuba diving, and boating in the unpredictable waters.

Risk Management

Scientists track the rate and composition of Jacuzzi-like bubbles in the shallows to gauge the volcanic and gaseous activity's threat to the local population. A large gas release could be lethal; noxious discharge can suffocate anything unlucky enough to be in the water or on its surface.



Seawater enters cracks in rock and mixes with magma gases, releasing hot water and bubbles.

Fragile chimneys form from crystallized particles carried in those acidic discharges.

Large amounts of gases can suddenly escape, killing organisms and cratering the seafloor.

as if we are swimming through upside-down rain. Everywhere I look, I see the effect of this acidity on marine life, as the undersea landscape is barren of corals and hard-shelled organisms. A careless marine worm settled too close to the bubbles. Its calcareous tube is already dissolving. Elsewhere, the seagrass meadows of *Posidonia,* also known as Neptune grass, display whitened, burned leaves.

Only anaerobic bacteria, which do not need oxygen to survive, appear to flourish. On rocky walls, they form a thick felt covering that gently undulates under acidic caresses. We too feel the acid burning our faces, and when we resurface after a few hours in pungent surroundings, our lips and cheeks are chapped and the chrome taps on our diving suits have oxidized.

O**FF PANAREA,** scientists operate a monitoring station that tracks the bubble sounds for signs of volcanic activity increasing or tapering off. Italiano has linked an increase in bubble noise to a large eruption on Stromboli. But to prove his findings, he needs more evidence and wants our help exploring a unique site he discovered a decade ago during an expedition mapping the seabed. Sonar identified a narrow valley situated in a strangely perfect axis between Panarea and Stromboli, 12 miles away. The site is 300 feet long and 50 feet wide. Extending across it as far as the eye can see is a collection of thin, high chimneys of crystallized iron oxides that formed over thousands of years. Italiano named it the Valley of 200 Volcanoes.

We descend 250 feet. The landscape looks Martian red, orange, and yellow, though unlike the red planet, this forbidding place is alive, as if suffocating from excess activity. It exhales, it grumbles, it spits. Gas and hot water escape from the tops of the narrow chimneys, and while one chimney is being built, another seems to be dying out and a third is already collapsing. There is a great sense of precariousness here, but underwater life is like that—at once fragile and obstinate.

I watch a small flatworm slide incognito across the leaves of the pioneer algae that cover a chimney's red slopes with a miniature forest, green with hope. The flatworm, smaller than my fingernail, is quite daring: It ventures to the top of the hydrothermal vents. It's difficult to



Colonies of anaerobic bacteria undulate on a rock wall near hydrothermal vents on the ocean floor. Bubbles of carbon dioxide, hot water, and sulfurous gases from the vents make life inhospitable for many life-forms.



understand what interest it might have in walking on iron oxides in acidic water loaded with carbon dioxide.

Amid this same inhospitable environment a marine pantopod, or sea spider, appears. Its long legs converge toward a body so tiny it's almost nonexistent. The only other place I have seen one this size is Antarctica.

To collect samples for Italiano, we insert a thermometer into the small vents at the top of the chimneys and take a vial of hot water and another of gas. We have time to sample only 20 before we have to resurface. We've been on the bottom for an hour and must spend three more on the way up to allow us and our samples time to decompress.

Finally, aboard the *Victoria IV,* we head to Stromboli, whose smoking summit can be seen in the distance. Frequent tremors have caused the peak to slough off soil, rock, and sand, destroying everything in its path. One side of Stromboli is green with olive and fig trees; the other is a blackened corridor through which lava flows and the rocky debris slides into the sea. The seabed is constantly redesigned after successive disasters, and I'm curious to see how the ecosystem below has recovered after the last major landslide, in 2002.

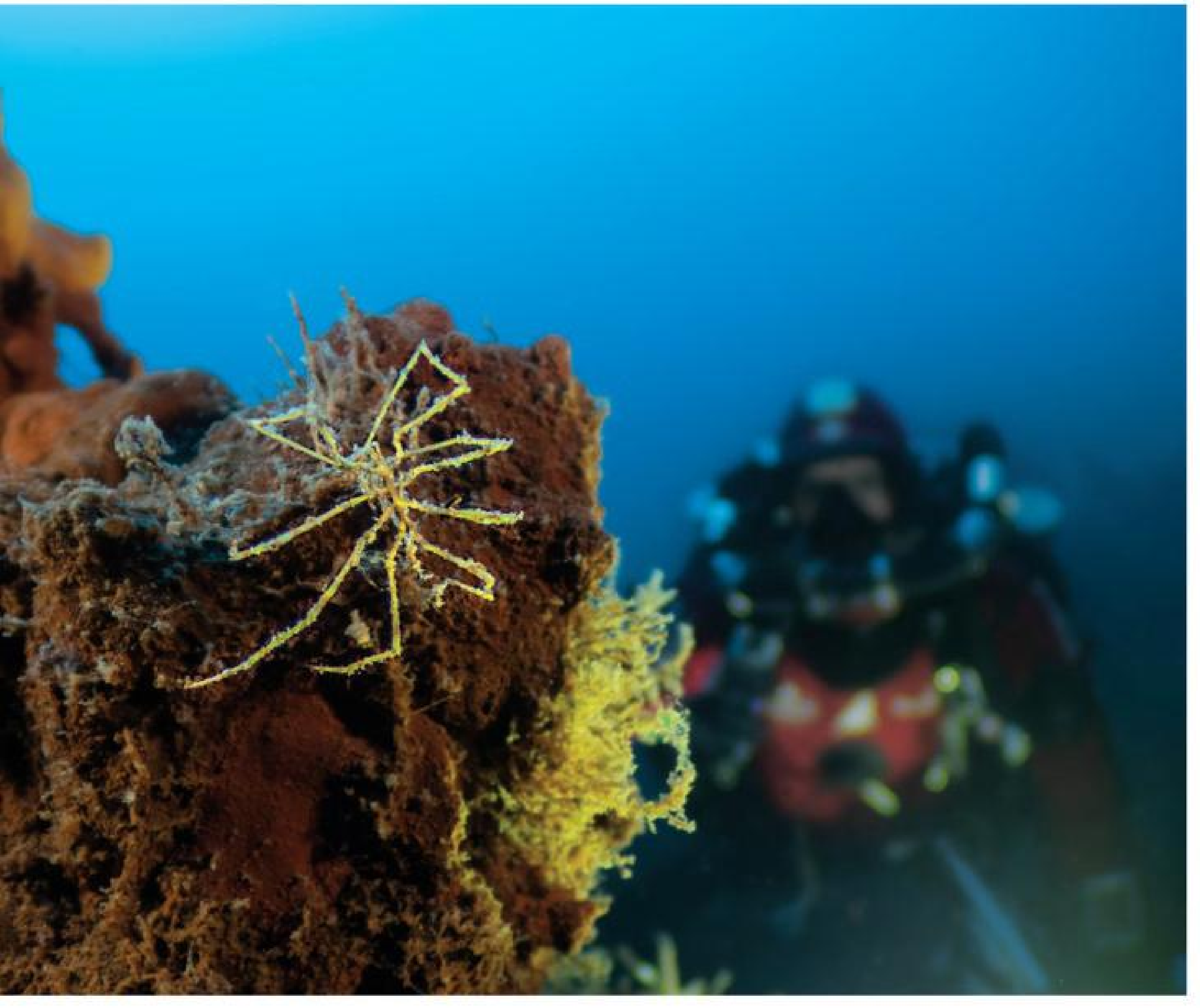




An area nicknamed the “Valley of 200 Volcanoes” lies on a perfect axis between two peaks in the Aeolian island chain. These tall, narrow chimneys formed over thousands of years when hot iron oxides released from undersea vents crystallized in the cold sea.





THERE IS A GREAT SENSE OF PRECARIOUSNESS HERE, BUT UNDERWATER LIFE IS LIKE THAT–AT ONCE FRAGILE AND OBSTINATE.



Even in harsh places, marine creatures can thrive. Clockwise from top left: The starfish *Peltaster placenta* is called a biscuit star because it looks like a cookie; a pantopod, or sea spider, wanders on top of a hydrothermal vent; *Diaphorodoris papillata,* a red-billed sea slug, roams the debris left after a lava flow; and the presence of *Lophius piscatorius,* a carnivorous angler-fish, shows that the whole food chain is once again in place.

As we descend, fields of *Cystoseira,* bushes of yellow-hued algae brimming with hidden marine animal life, disappear abruptly into black sand and jagged stones. One might think we were on a barren planet if an anglerfish hadn't appeared in the black silica dust raised by our fins. On closer inspection, we spot a series of pioneering species that have begun their work of reclaiming the area. Nearby, a field of white gorgonian corals survived a close call: It is half-buried in black sand of a recent flow but still alive. Then a juvenile dogfish, about eight inches long, cruises by. This baby shark, whose fate is uncertain, is a perfect symbol of a reborn ecosystem.

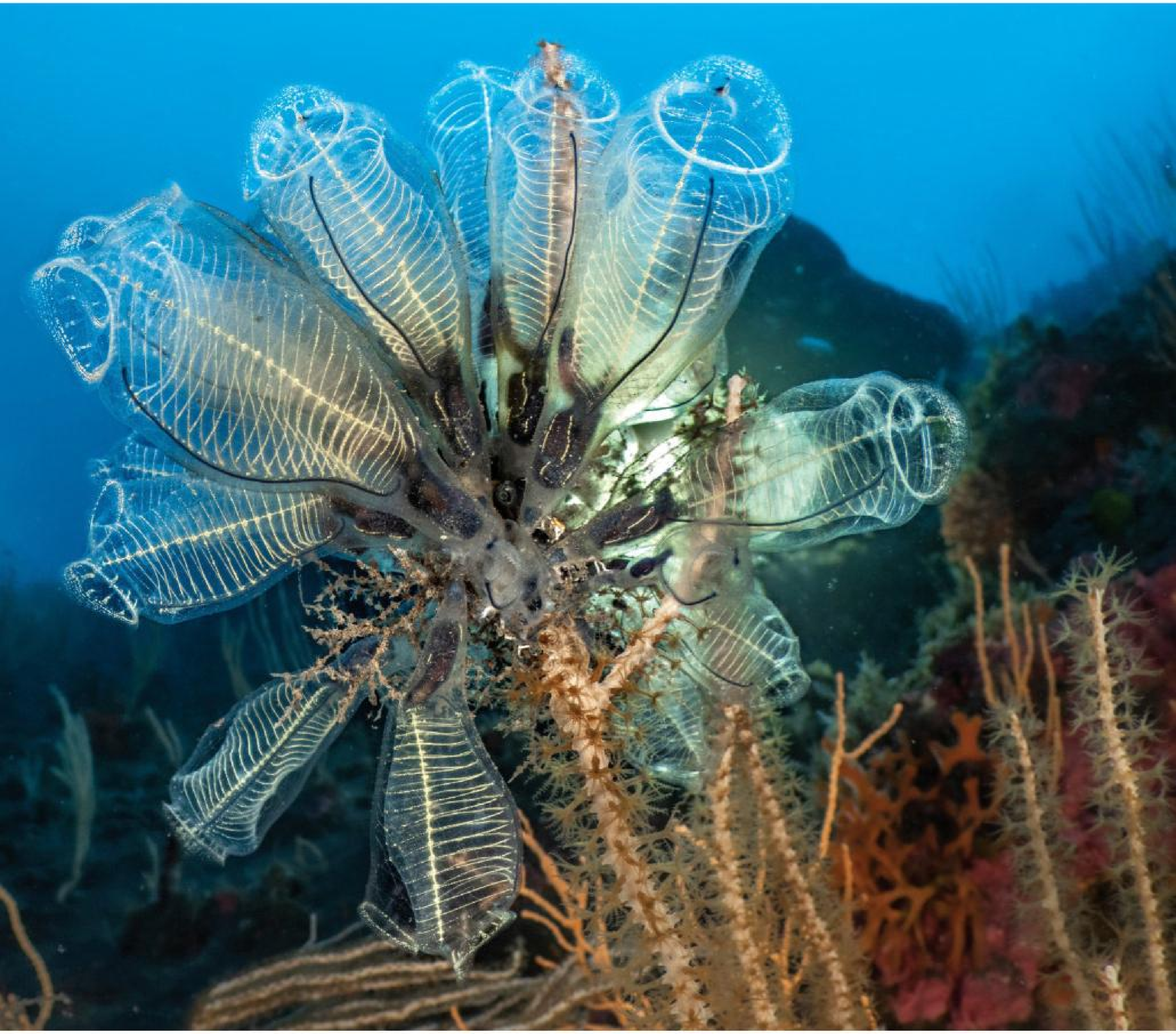
Successive landslides have also miraculously spared a magnificent pinnacle of volcanic rock, an upright needle towering 130 feet. Rinaldi found it 30 years ago, and when we locate it along the rearranged seafloor, we find it hosting flourishing underwater life precisely because it has been spared. It's common to talk about the fragility of nature, yet nature clings on, resists, and bides its time.

After three weeks at the foot of volcanoes, we made our last dives in the Bay of Naples, about a mile offshore from Italy's third largest city, where Rinaldi wanted to explore a hole in the bottom of the sea. Researchers know nothing about it, but the hole is the stuff of legend among local fishermen. It's said a mysterious "mouth" exists at the bottom of the bay, which swallows their nets, lines, and traps, never to be seen again. To say this dive is attractive would be an outright lie. The water is green, murky, and cold—and the muddy seabed is littered with trash. There is nothing to see, but there is a sense of curiosity to be satisfied. Can it really be that on this seabed, soft and flat for miles around, lies the entrance to a vertical, rocky cave so mysterious that no instrument has ever probed its depths?

As we descend, suddenly we reach the edge of the opening. The soft mud gives way to black rock. My depth gauge shows we are 165 feet down when we tip into the black hole. The water is too murky to see the whole perimeter, but one can imagine a large well measuring probably more than 30 feet in diameter. At 250 feet, the cylinder opens up into an abyss so large that the beam of our lamps cannot locate a wall. At 310 feet, we touch bottom. Looking up, we can still make out a small green glow at the shaft entrance, so



Shaped like crystal bells, giant invertebrates called *Clavelina dellavallei* seem to find ideal conditions here—meaning an absence of competitive species. Few other places like this exist in the Mediterranean.

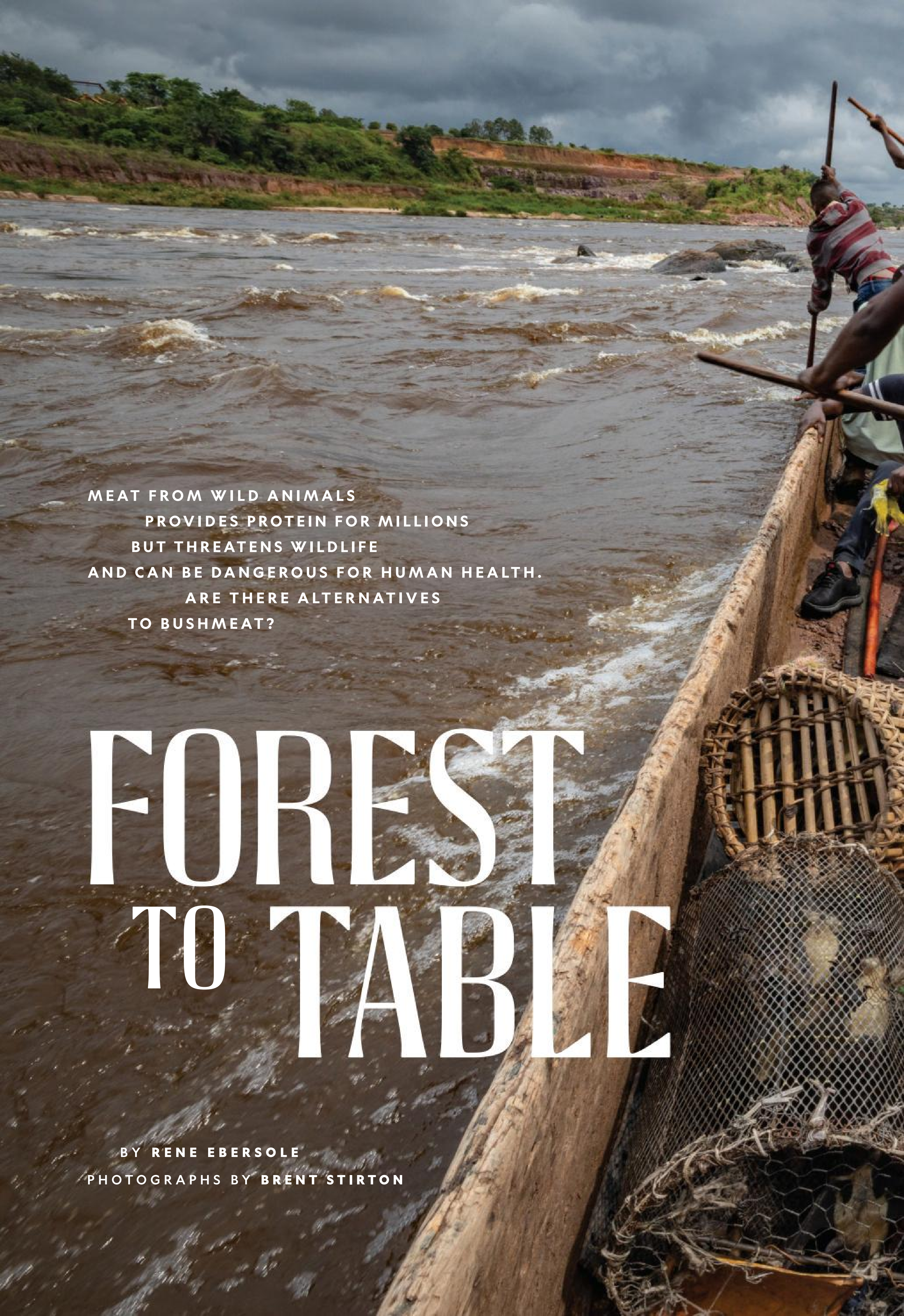


far away that it looks like a small mousehole. We find the chamber's walls and discover an ecosystem has established itself here. The walls of black rock are covered with small filter-feeding invertebrates and crossed by rare long-clawed crustaceans. Among the creatures living on borrowed time, we identify a rare species: a carnivorous sponge.

A sonar image solves the mystery of where we are: in the center of a huge circular chamber, as if we are in a gigantic wine carafe with a long, narrow neck suddenly widening into a large basin. It is probably an ancient magma chamber emptied of its lava. Sooner or later it will collapse inward, generating a small tsunami that will gently lap against Naples's beaches. We have brought equipment for scientists and install it on the chamber's floor to measure water circulation, temperature, acidity, and secrets of the deep.

We ascend with a strange sensation. Our journey began in a familiar world—with the sky, the surface of the sea, the sea, and the seabed. We did not dive to the bottom of the sea, but rather *under* the bottom of the sea. And there is life. ▯

French biologist, photographer, and deep-sea diver **Laurent Ballesta** spent 28 days photographing the Mediterranean seafloor for *National Geographic's* May 2021 issue.



MEAT FROM WILD ANIMALS PROVIDES PROTEIN FOR MILLIONS BUT THREATENS WILDLIFE AND CAN BE DANGEROUS FOR HUMAN HEALTH. ARE THERE ALTERNATIVES TO BUSHMEAT?

FOREST TO TABLE

BY **RENE EBERSOLE**
PHOTOGRAPHS BY **BRENT STIRTON**



A boatful of bats netted on a small forested island in the Congo River is destined for markets in Brazzaville, the capital of the Republic of the Congo, where customers buy them for cooking and eating.





Market vendors selling fruit bats in Brazzaville often use their teeth to debone the bats' wings for their customers. Bats are common vectors for many diseases.



Indigenous Mbuti in the Democratic Republic of the Congo hunt wild animals for subsistence using nets crafted from forest vines. Women shout to drive prey toward the men's nets. The hunters catch mostly small animals such as duikers.



Instead of wild meats, chef Honor Toudissa's Congolese cuisine uses fresh and affordable natural ingredients bought at outdoor markets in Brazzaville. A signature dish, *liboké,* is wrapped in arrowroot leaves.



B

BENEATH A RAINBOW of colorful shade umbrellas, Poto Poto Market clamors with merchants selling goods: smoked fish, papayas, eggplants, dresses, children's school supplies, flip-flops. It's a Saturday morning in Brazzaville, the pulsing capital of the Republic of the Congo, and Honor Toudissa, strolling the aisles, pauses to examine two large catfish thrashing in a shallow bin of water. He offers a woman wearing a



HONOR TOUDISSA'S MISSION IS
TO DEMONSTRATE THAT IT'S POSSIBLE
TO COOK CONGOLESE-STYLE
FOOD WITHOUT USING WILD GAME.

pink T-shirt and yellow headscarf seven dollars for the pair. Pleased, she places the fish on her wooden butcher block and chops their heads off with her machete: *Whack!*

Toudissa, who has appeared on Congolese television and in international cooking competitions, is buying fresh catfish to make a traditional dish called *liboké*. He'll marinate them by hand in garlic, pepper, oil, and basil, wrap the mixed ingredients in arrowroot leaves cinched with string, and grill the bundles over a charcoal fire. From other merchants he buys beef raised by local pastoral cattle herders rather than on industrial farms in Brazil, Germany, and other faraway countries. He also buys ginger, green onions, and live crickets and grubs—insects considered a delicacy here. Toudissa likes to use them in a green mango salad and chocolaty desserts.

Eleven years ago, Toudissa's popular Brazzaville restaurant, Espace Liboké, was destroyed when a military arms depot exploded, killing 246 people. His latest culinary venture is part of a mission to demonstrate that it's possible to cook Congolese-style food without using wild game—bushmeat as it's commonly called. Eating wild meat—everything from antelope, monkeys, and porcupines to endangered gorillas, elephants, and pangolins—has always been part of his country's culture. But Toudissa is bucking the status quo. "If we kill all the animals, people will not have a chance to see them," he said as we walked the crowded market aisles. "My food is natural. It comes from the water, farms, and forests—and it doesn't include bushmeat."

Toudissa is part of a novel campaign led by local Congolese staff with the Wildlife Conservation Society (WCS), a nonprofit headquartered in New York City that works to protect wildlife from poaching and other environmental threats. Focused on positive messaging rather than telling people what not to eat, the program celebrates the region's gastronomy. Billboards, TV advertisements, YouTube cooking demonstrations, and a catchy jingle promote wild-meat-free Congolese recipes as *yoka pimbo!*—delicious!

The commercial wild meat trade is emptying forests in Africa and around the globe. Studies show that bushmeat consumption threatens more than 300 species of terrestrial mammals with extinction. Hunters target 200 species in the Amazon Basin, amounting to more than a million tons of meat annually. In Asia, rising demand in cities has created a booming market. In Vietnam, affluent men want wild meat as a way of signaling prestige and gaining social status, according to studies published during the past decade. In Madagascar, lemurs, which draw tourists from around the world, also appear on dinner tables in rural households. A shift to luxury consumption in cities, where bushmeat sells for twice the price, could threaten the survival of certain lemur species.

Wild meat can be found even in major European and U.S. cities. In 2019 the U.K.'s Border Force, the agency that secures the country's ports, seized more than 2,200 pounds of wild meat, including chimpanzee and giraffe, from travelers entering the country. During the Christmas season in 2021, U.S. Customs and Border Protection agents at Minneapolis-St. Paul International Airport confiscated more than a hundred pounds of wild meat in one week.

For many rural communities in Central Africa, bushmeat has long been a staple food. But now what worries conservation groups most is the toll of overhunting on fragile forest ecosystems, driven by soaring demand for wild meat in big cities, particularly in Brazzaville and neighboring Kinshasa, the capital of the Democratic Republic of the Congo, which have a combined population of 16 million.

"Every year, more than five million tons of bushmeat are extracted from forests in the Congo Basin, and most of that is going to urban centers—not for subsistence but as a luxury product," said Lude Kinzonzi. A campaign assistant with the WCS's Bushmeat Project, which is attempting to protect wildlife by reducing urban demand for meat from the wild, Kinzonzi accompanied me on a three-week tour of the Republic of the Congo for a close look at the wild meat trade. If "extraction continues at this level, some wildlife will become

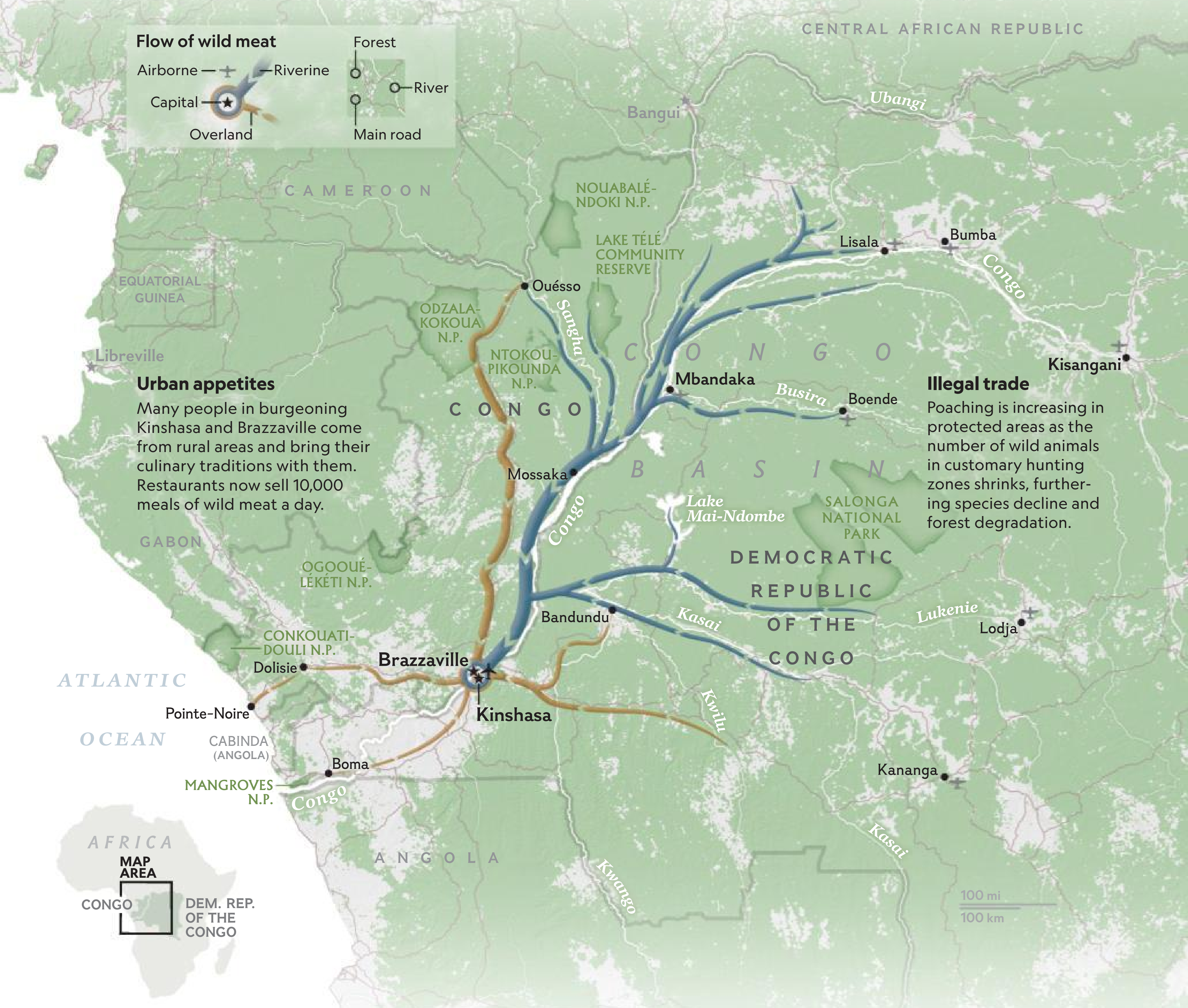


The National Geographic Society, committed to illuminating and protecting the wonder of our world, has funded Explorer Brent Stirton's work around illegal wildlife trade since 2016.

ILLUSTRATION BY JOE MCKENDRY

TASTE OF THE WILD

In the Congo Basin tens of millions of animals are hunted each year, some illegally in protected areas. Wild meat is a food and income source for communities that trade along routes connecting forests with villages and cities. Rising demand in cities, however, is diminishing both animal populations and rural families' access to food.



Urban appetites

Many people in burgeoning Kinshasa and Brazzaville come from rural areas and bring their culinary traditions with them. Restaurants now sell 10,000 meals of wild meat a day.

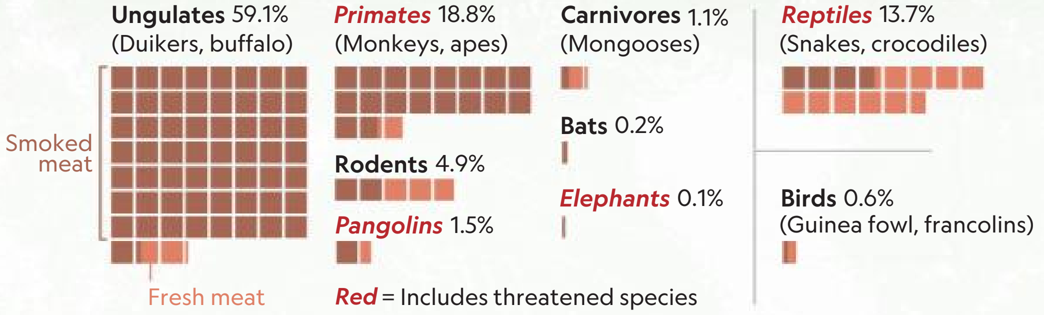
Illegal trade

Poaching is increasing in protected areas as the number of wild animals in customary hunting zones shrinks, furthering species decline and forest degradation.

Bushmeat business

When smoked, wild meat can last up to six weeks without refrigeration. Duiker (an African antelope) meat is most abundant in markets. But shoppers can also find meat from vulnerable or endangered species, such as pangolins, chimpanzees, and elephants.

Mammal, reptile, and bird meat for sale in six Kinshasa markets*



*BY TOTAL WEIGHT, AUGUST-OCTOBER 2016

CHRISTINE FELLENZ AND DIANA MARQUES, NGM STAFF; KELSEY NOWAKOWSKI. SOURCES: JULIET WRIGHT, DIVIN MALEKANI, AND SAMUEL BAMUE, WCS; THEODORE TREFON AND KROSSY MAVAKALA, ERAIFT; DANIEL INGRAM, UNIVERSITY OF KENT; ERIC NANA, LAUREN COAD, AND JASMIN WILLIS, UNIVERSITY OF OXFORD; VAINQUEUR PEMBELA, UNIVERSITY OF KINSHASA



Boats bring wild meat to the port in Kinshasa, the DRC's capital, predicted to become the world's fourth largest city by 2050. The dwarf crocodile seen here is a vulnerable species.



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extinct," he said. "We're hoping that the campaign can convince people in cities to choose locally raised alternatives to bushmeat."

LATELY, DURING WHAT MAY BE the worst pandemic since the Black Death of the mid-1300s, debates about how to thwart infectious diseases transmitted from wildlife to people have overtaken concerns about declining biodiversity resulting from the wild meat trade. More than 70 percent of diseases that have emerged in humans since the 1940s—including Ebola, HIV, monkeypox, and coronaviruses—came from wildlife. Human activity is the main cause of outbreaks, particularly our intrusion into wilderness areas for logging and farming, and the trading and eating of wild animals. A recent study of 16 commonly eaten species at wildlife markets in China found 71 mammalian viruses in the meat, including 18 of "potentially high risk" to people and domestic animals.

Amid ongoing discussions over the origins of COVID-19—which has killed nearly seven million people since it emerged in December 2019—some global health experts and animal activist groups have called for permanent bans on wild meat markets. Opponents argue that market closures could lead to food shortages and economic instability in impoverished regions. Others say that biodiversity and human health protections require instead a combination of more regulatory oversight of markets, limited wildlife sales, and a gradual cultural shift away from eating wild meat.

Since 2018, a consortium including WCS and the UN Food and Agriculture Organization has implemented the Sustainable Wildlife Management Programme in Central Africa, a hot spot for emerging animal-borne diseases. The program aims to fight the problem on several fronts: reducing luxury consumption of wild meat in towns and cities, supporting sustainable hunting initiatives, developing local farming ventures that can provide alternatives to wild meat, and undertaking wildlife disease research that can help inform public health decisions.

One obstacle to changing consumer behavior is a prejudice against frozen meats, including imported chicken, beef, and pork, which aren't seen as "natural." Research by WCS in three Central African cities (Pointe-Noire, Brazzaville, and Kinshasa) shows that 85 percent of people eat wild meat when they have the opportunity to do so and 24 percent of restaurants, which are sometimes based in private homes, sell wild meat.



Savoir Manger (French for "know how to eat") in downtown Brazzaville sells only wild meat. Owner Stany Morobo welcomed Kinzonzi and me through a narrow cast-iron gate into a concrete courtyard situated between his house and a shaded dining area built from wood planks painted blue. T-shirts and towels hung on a washing line, and a pot of water was boiling on an open fire. The menu, written in

THE SUSTAINABLE WILDLIFE MANAGEMENT PROGRAMME SUPPORTED BRENT STIRTON'S WORK ON THIS PROJECT.



Likely orphaned when its mother was killed for meat, a baby chimpanzee finds safe haven at Lwiro Primates Rehabilitation Center, in South Kivu, DRC. If they aren't rescued, orphaned chimps are often sold into the illegal pet trade.

white paint on the back of the entryway gate, offered fresh antelope, porcupine, pangolin, monkey, civet, python, and cane rat. "Pay before you eat: $1500 xaf [about U.S. $2.50], *Bon Appetit*."

Morobo said his refrigerator was broken, so he had no food to offer, but smiling, he talked proudly about his cuisine. "It's fresh meat, prepared naturally without a lot of seasoning so the taste really comes out," he said. His most popular dishes are porcupine, monkey, pangolin, and red river hog. In some recipes, the meat's juices meld in a broth of tomatoes, onions, and garlic. Every meal is spiced to taste with red chili pepper and sopped up with traditional doughy bread made from cassava flour.

Morobo said he buys his meat directly from hunters in villages close to forests. He knows that some threatened species are prohibited. "Normally, python and pangolin are not authorized, and some monkeys are illegal to sell," he said. "It can be difficult to get them. You just have to be really careful. If the ecoguards catch you, you'll get five years in prison." He evades them by hiding the meat in his car, he explained. Morobo often supplies wild meat to other restaurants, private homes, and even travelers from France and other far-off places who sneak meat home in their suitcases. "People are lovers of this meat," he said. "They like it so much. They have to have it."



Women sell a variety of wild meat, from dwarf crocodiles and antelope to monkeys and bushpigs, at a popular night market in Brazzaville. Endangered elephants and pangolins, prohibited from trade, are sometimes sold covertly.



EVEN THOUGH KINZONZI seeks to reduce the consumption of wild meat, he understands the craving for it. When Kinzonzi was a boy, his father would often cook meat from the forest for his family. Grilled civet, a catlike mammal with a long body, thick furry tail, and short legs, was his favorite. "Eating bushmeat is part of my culture," he said. "But if we want people to change their behavior, I needed to be the first person to move in that direction." Kinzonzi added that he took his last bite from the wild four years ago.

Recently he and his colleagues have seen a worrying trend in some markets. Every day from late September through early December in Total Market in downtown Brazzaville, men prepare live straw-colored fruit bats for customers' cook pots. First, they kill the bats with a smack on the concrete. Then they debone the wings with their teeth. Worldwide, fruit bats are commonly eaten by people living close to forests, but some wildlife and public health experts are concerned about this commercial-scale trade, particularly when preparation exposes people to bats' bodily fluids.

Early one morning, Kinzonzi and I left Brazzaville and joined David Lakoutelamio and three fellow bat collectors along the banks of the Congo River. The men loaded oblong wooden cages into a dugout canoe. Paddling hard across the river's strong current, they charted a course for the tiny island of Île de Chie in the middle of the river. Lakoutelamio traipsed into the forest to check his 14 mesh mist nets, each spanning more than two school buses in length and at least two stories in height. As he lowered a net with a rope and worked on removing a bat, I asked if he worries about being exposed to a disease through his close interaction with the animals. He replied that it's not possible to get diseases from these bats because they eat healthy diets of mainly fruits. "If a bat bites you, it will hurt a lot," he said, "but it won't make you sick."

With ironclad immune systems, bats can be infected with viruses and not fall sick. This makes them ideally suited for spreading disease to humans in close contact with them. If a person happens to encounter a bat's blood or body fluids when it's shedding a virus, there's an opportunity for a disease to spill over.

Children at a Kinshasa orphanage eat palm weevil larvae, called *mpose,* a popular protein alternative to meat. Farms for Orphans, a nonprofit, raises the mpose, which conservationists hope can eventually sustain villages.



‘IF WE WANT PEOPLE TO CHANGE THEIR BEHAVIOR, I NEEDED TO BE THE FIRST PERSON TO MOVE IN THAT DIRECTION.’

—Lude Kinzonzi, Wildlife Conservation Society







Every three years, villagers enjoy a fishing festival, featuring handmade nets and baskets, near Pendjari National Park, in the West African country of Benin. The festival, in honor of the community's heritage, began after authorities banned fishing camps in the park, which were being used by poachers.

A Wildlife Conservation Society field-worker collects information about animals such as these duikers shot in a logging concession where regulated hunting is permitted. Long-term monitoring helps provide an indication of the forest's biodiversity and whether the hunting is sustainable.



Bats have long been suspected as the likely vector for Ebola and other disease outbreaks, and they remain a target for researchers studying animals capable of harboring a wide array of diseases. In a study published in 2021, a consortium of researchers with funding from USAID tested more than 3,500 bats, rodents, and primates in the Congo Basin for any sign of coronavirus. They found the marker sequences in 121 animals, of which all but two were bats.

WCS has launched a new study to learn more about bat hunting on Île de Chie and at other sites, including blood testing to ascertain whether the animals are carrying antibodies for Ebola and other diseases. "This bat trade seems risky from a health perspective," Michelle Wieland, WCS's Africa director for rights and communities, says. "It could be ground zero for another outbreak."

MUCH OF THE WILD meat in Brazzaville funnels through the city of Ouésso, on the west bank of the Sangha River, more than 500 miles to the north. With about 30,000 people, Ouésso is what's considered protein poor, and eating food from the forest is not a luxury but a necessity. Diets here include fish, wild meats, vegetables, cassava bread, and domestic and imported meats.



Ouésso is both a port and a gateway to northern logging concessions ringing one of the most remote rainforests on the planet, the more than 1,500-square-mile Nouabalé-Ndoki National Park, on the border of the Central African Republic. Each day at sunrise, dugouts leave Ouésso to collect wild meat from dozens of tiny villages along the riverbanks. When the boats return, young men cart the goods to the town markets, where some meat is smoked on the spot and women with babies swaddled on their backs barter with vendors for the best prices.

More than 80 ecoguards, employed by the government, operate mobile patrols to prevent hunters and ivory poachers from penetrating Nouabalé-Ndoki, which *Time* magazine once called the Last Eden for its pristine forests, western lowland gorillas, chimpanzees, and forest elephants. Interactions between ecoguards and local communities have caused conflict, but the prevention of poaching has been effective. Guards caught an ivory poacher, Mobanza Mobembo Gerard, who with 25 accomplices killed an estimated 500 elephants between 2008 and 2020. His 30-year prison sentence for killing elephants and shooting at the guards was the most severe penalty ever given for a wildlife crime in the region.

Gorillas, elephants, and chimpanzees, all endangered, used to be common in Ouésso's markets. Increased protections and the threat of a prison sentence for anyone caught killing or transporting those animals have made it rare now to find them for sale, though officials suspect they're still sold secretly. At Ouésso's main market, I saw antelope and monkey meat being smoked on charcoal pyres. Sellers butchered animals as they arrived. Humanlike hands and feet of putty-nosed monkeys, identifiable by the white patch on their noses, and De Brazza's monkeys, named for the Italian explorer who founded Brazzaville, lay discarded at the edge of chopping blocks.

Because it's impossible to know where the animals were killed, there's no way to determine if they were hunted legally. So police stick to enforcing laws related to protected species. One meat vendor told me she wished she could go back to selling gorilla, elephant, and bongo (a protected antelope); that would make her rich, she said. "People would celebrate."

Most wild meat pouring into Ouésso—and beyond to Brazzaville and Kinshasa, where it's sold for more than twice the price—is supplied by small hunting camps, rural forest villages, and logging concessions. These concessions are ubiquitous, Wieland says, and many timber companies don't care if their truck drivers carry illegal bushmeat. But one company, Congolaise Industrielle des Bois, has been working with WCS and the government's Ministry of Forest Economy for almost 24 years to provide a better example. Along with WCS, the company funds a program that pays for ecoguards to patrol timber concessions and transit routes for bushmeat traffickers and supports sustainable hunting for its workers, who in the past have hired Indigenous hunter-gatherers to kill animals. A Ba'Aka man, Richard Bokoba, told me



MORE THAN 70 PERCENT OF DISEASES
THAT HAVE EMERGED IN HUMANS SINCE THE
1940S—INCLUDING EBOLA, HIV,
AND CORONAVIRUSES—CAME FROM WILDLIFE.

the loggers either give him cash—a red duiker carcass gets about $25—or they let him keep the intestines to feed himself, his wife, and their five children. Because the family can live on plants, mushrooms, and small rodents, Bokoba said, he usually takes the money for cooking oil, medicine, sometimes clothing.

In addition to promoting sustainable hunting, the program supports small-scale livestock farming in places like Ouésso, where I met Pierrette Bouesso, who sells homemade yogurt, cakes, and Congolese dishes. She was preparing to receive 200 chickens from the program's husbandry initiative, which had also provided some small business training. Her chicken will be costlier than supermarket poultry but more ecologically sustainable than bushmeat, and she's confident she'll have buyers. A divorced woman supporting children and grandchildren, she said the additional income will be very helpful in providing for her family's needs.

In Brazzaville and other major cities, eating bushmeat is like dining on lobster in the United States—a luxury. As we sat for a meal at Chef Toudissa's table, Kinzonzi told me people sometimes ask him, If I don't buy bushmeat, what will I buy? Imported meat that can make me sick? This, he said, is how he replies: "No, if you can afford bushmeat, you can afford goat, or beef, or local chicken."

Toudissa is showing people how to savor the flavors of their heritage without wiping out wildlife. As the sun set, he presented an appetizer of crickets and grubs sautéed with fresh mangoes gathered from the trees in his yard. The grubs were shrimplike in texture. Two types of liboké, catfish and beef, were stewed in herbs, tomatoes, cucumbers, and garlic. The beef was tender and the fish savory in its pepper and onion broth. A cassava pudding was topped with sweet jams made from mangoes and a rainforest fruit called *mbila ya esobe.*

The meal was among the first of many that Toudissa planned to host in his courtyard, where he's building a culinary school, Village Liboké, to teach others, from small children to professional chefs, to cook bushmeat-free Congolese cuisine, preserving the forests and the animals living in them. ▫



The commercial wildlife trade risks spreading disease. Suffering from monkeypox, Blandine Bosaku, 18, and her daughter Anisha Yaiteni, six, spend time in a hospital isolation ward in the DRC's Équateur Province after Bosaku's older daughter died from the disease.

Rene Ebersole is a frequent contributor to National Geographic's Wildlife Watch. **Brent Stirton'**s images were recognized by the Wildlife Photographer of the Year contest and Visa Pour l'Image.



METAL FROM THE HEAVENS

Before people learned how to smelt iron, early cultures used iron from meteorites to craft ornaments and weapons.

BY **JAY BENNETT**

ILLUSTRATIONS BY **OWEN FREEMAN**

PHOTOGRAPHS BY **PAOLO VERZONE**

ROYAL BLADES

In ancient China, artisans made a unique weapon called a *ge,* which has a dagger-ax attached to a shaft. Some, crafted from meteoritic metal, are believed to have been treasured by royalty for ceremonial purposes. It's not known if the Chinese understood that this metal fell from the sky, but they paid careful attention to celestial phenomena.







HIGHLY SKILLED CRAFTSMANSHIP

A ge with a meteoritic iron blade mounted in bronze was found in the tomb of a ruler from the eighth or ninth century B.C. The weapon represents an innovation in metalworking: casting bronze around a premade iron blade. Similar weapons with smelted iron blades suggest meteoritic metal could have informed early ironworking techniques.

PHOTO: ZHAO ANG, GUO STATE MUSEUM, SANMENXIA, CHINA
BACKGROUND: OWEN FREEMAN


Hraschina
(IID/Om)
Kroatien
Croatia
Fall 26.05.1751
(fall)

INSIDE A 4,400-YEAR-OLD ROYAL TOMB IN EGYPT, I STUDIED THE WALLS SEARCHING FOR A PARTICULAR SYMBOL.

The shapes of one of the oldest writing systems—vultures and owls, eyes and feet, snakes and half circles—were etched into the limestone in neat columns. Flecks of brilliant blue pigment, a prized adornment in the Old Kingdom, still lined the crevices of the hieroglyphs.

The symbol I was trying to find looks something like a bowl with a horizontal line just beneath the brim, as if it were filled with water. Fluorescent lights on the floor lit the dim antechamber, casting shadows across the texts as tourists and guides milled about. Rows of carved five-pointed stars covered the vaulted ceiling.

Egyptologist Victoria Almansa-Villatoro scanned the hieroglyphs with two extended fingers. Wearing a white baseball cap, a magenta backpack, and Nike sneakers with a pink swoosh, she cut an image of modernity, striking in that ancient place. A scholar of Old Kingdom texts with the Harvard Society of Fellows, Almansa-Villatoro had agreed to show me the tombs of Saqqara, about 15 miles south of Cairo.

This burial place belonged to Unas, the last ruler of the 5th dynasty from the 24th century B.C. The passages on the walls, called spells by Egyptologists, were intended to guide the

OBJECT OF FASCINATION

In 1751 a meteorite landed in Hrašćina, Croatia, with witnesses reporting an explosion and a fireball in the sky—claims that were later dismissed as fairy tales. Weighing 88 pounds, the largest chunk of that meteorite is displayed in the Natural History Museum Vienna.


FRIEDEL
Minéralogie
1893.
Fuchs,
1890.
4. Aufl.
1898.
5. Aufl.
1907.
GALLITZIN
Gössel's
Mineralogie
1 — 5.
Nord
CARTE
des Lieux sur lesquels a éclaté
le Météore du 6 Floréal An XI
aux environs de l'Aigle
Département de l'Orne
Couvain
Glos-
la Ferrierre
Gauville
St Pierre
St Nicolas
St Michel
St Symphorien
Ouest
Sud



HARD EVIDENCE PROVES DECISIVE

At the turn of the 19th century, scientists in Europe still debated the existence of meteorites. Then, in 1803, one exploded in the sky and rained about 3,000 stones on L'Aigle, France. Some of the stones are displayed at the Natural History Museum Vienna, along with a report from a scientist who investigated and declared the event "the most astonishing phenomenon ever observed by man."

deceased king through the perils of the afterlife. They are the oldest such writings, collectively known as the Pyramid Texts.

Almansa-Villatoro's fingers froze over a column of symbols next to the passageway to Unas's sarcophagus. "There you go," she whispered excitedly, pointing to the U-shaped marking.

The symbol, Almansa-Villatoro's research suggests, was used to refer to iron—a remarkable thing for Egyptians to write about at that time. It would be roughly a thousand years before humans learned to reliably smelt iron. But there is another source of the metal: meteorites.

Within the past decade, studies of artifacts have confirmed that some civilizations used iron from meteorites to craft objects before smelted iron was available. In a cemetery on the Nile called Gerzeh, dated to about 5,200 years ago, archaeologists discovered nine beads made of meteoritic metal. An exquisitely made polished dagger and other meteoritic iron objects were among the treasures sealed in Tutankhamun's tomb about 3,300 years ago. Ancient jewelry and weapons made from this rare material have also cropped up in other parts of the world: beads in North America, axes in China, and a dagger in Turkey.

In most cases, it isn't known whether these cultures understood where meteorites came from. In the tomb of Unas, however, the funerary texts tell of metal in the sky, suggesting Egyptians may have not only recognized the phenomenon of falling iron but also incorporated it into their mystical beliefs.

Almansa-Villatoro broke down the semantics of the sentence for me. She pointed out an arched symbol meaning "sky" and a teardrop-shaped glyph indicating "metals." Together with the bowl symbol, these hieroglyphs refer to a metal belonging to the sky, she explained.

"Unas seizes—grabs—the sky and splits its iron," she translated.

This line describes the journey of Unas into the divine realm of the sky. The exact meaning is obscure, but Almansa-Villatoro argues the passage reflects a belief that the sky is a great water-filled iron basin from which rain and metal sometimes fall. To reach the afterlife, the Pyramid Texts tell us, the king must sail across this celestial domain.

The texts, which also appear in the tombs of later rulers, include other equally abstruse references. "The iron door in the starry sky is pulled open," reads one line, according to Almansa-Villatoro's translations. They also tell of an "egg" of iron, a possible metaphor for the womb of the Egyptian sky goddess Nut. "He will break the iron after he has split the egg," another line says.

"Iron has all these cosmological connotations with creation and, therefore, resurrection," Almansa-Villatoro says. To split the iron egg of the sky is to return to the womb to be reborn.

METEORITES: FROM MYTH TO FACT

ROCK AND METAL have pummeled Earth since its earliest days, mostly fragments of planetary bodies pulverized in collisions. Every year, roughly 17,600 meteorites weighing more than 50 grams reach Earth. Most are primarily stone, but about 4 percent are iron-nickel alloys distinct from terrestrial iron. They usually land unnoticed, with people witnessing only about five of these falling objects a year.

The first dated account of a possible meteorite fall appears in the writings of ancient Greeks and Romans. Aristotle, Plutarch, and Pliny the Elder, among others, wrote about a stone landing in 467 or 466 B.C. in what is now Turkey. "It will not be doubted that stones do frequently fall," Pliny observed.

Plutarch also recounts a Roman military engagement in the first century B.C. that may have been interrupted by a meteorite. "As they were on the point of joining battle, with no apparent change of weather, but all on a sudden, the sky burst asunder, and a huge, flamelike body was seen to fall between the two armies," he wrote. "In shape, it was most like a wine jar and in color, like molten silver."

In 861, near a shrine in Nogata, Japan, according to oral traditions compiled in 1927, "a great detonation occurred," "a brilliant flash was seen," and "a black stone was found at the bottom of a newly made hole in the ground." In 1983 Japanese scientists studied the meteorite, which is kept in an old wooden box inscribed with the year. After carbon-dating the container, they concluded the stone likely fell as described.

In Europe, though, until the beginning of the 19th century, most scientists had been skeptical that meteorites were a real phenomenon. In April 1794 German scientist Ernst Chladni

published a book that compiled reports of stones and iron dropping from the sky—an endeavor that earned him ridicule.

Then the cosmos intervened. In June 1794 a hail of rocks was seen by witnesses outside of Siena, Italy. The next year a 56-pound stone fell in Wold Cottage, England.

The impacts prompted English chemist Edward C. Howard and French mineralogist Jacques-Louis de Bournon to collect samples from "fallen bodies." Their analyses, published in 1802, showed that four stony meteorites had compositions and structures unlike terrestrial rocks. Howard also measured high nickel content in three iron meteorites and one stony-iron meteorite, revealing the metal was distinct from that smelted from ore.

But it wasn't until 1803 that the European scientific community was fully convinced of what Pliny seemed sure of. That year, a meteorite shower pelted L'Aigle, France, with about 3,000 stones.

With that, scientific interest in meteorites grew. English naturalist James Sowerby amassed a collection in his personal museum, including the Wold Cottage meteorite. He was so infatuated with them that he used a piece of an iron one found in South Africa to have a sword forged for Tsar Alexander I of Russia to commemorate the defeat of Napoleon in 1814. The inscription he had engraved on the blade begins: "This Iron, having fallen from the Heavens …"

RARE METAL, PRECIOUS OBJECTS

WHETHER OR NOT they knew it came from the sky, ancient peoples valued meteoritic iron. Copper, silver, and gold exist in metallic form, available to be mined and worked, but on Earth, iron is almost always bound up with other elements, such as oxygen, in minerals called ores.

The oldest known objects fashioned from space metal were ornaments, such as the Gerzeh beads, some of which were strung along with gold and gemstones, including lapis lazuli, carnelian, and agate.

"In the beginning it was used for precious things, beads and representative stuff, because it was so exotic," says Katja Broschat, a restorer

IT WOULD BE ROUGHLY A THOUSAND YEARS BEFORE HUMANS LEARNED TO RELIABLY SMELT IRON. BUT THERE WAS ANOTHER SOURCE OF THE METAL: METEORITES.



JEWELRY FROM SPACE CRYSTALS

Two iron beads found in a burial mound in Illinois and now at the Smithsonian's National Museum of Natural History are seen against a cross section of the meteorite from which the ancient Hopewell people crafted them. Interweaving iron-nickel crystals create the distinct Widmanstätten pattern in the meteoritic metal, the result of slowly cooling within the core of a planetary body.
PHOTO: MARK THIESSEN



at the Leibniz Center for Archaeology in Mainz, Germany. "It took a while until the manufacturing technique ... was good enough to produce a weapon or tool material."

By the time Tut's dagger was made in the Late Bronze Age, artisans had learned to grind and polish the meteoritic metal into a fine blade. "It's very sharp," says Broschat, who has studied the artifact. "I'm sure you can kill an animal, or whatever, maybe even a man."

The knife has a gold hilt with stone and glass inlays, a pommel of rock crystal, and a gold sheath with elaborate designs. Found in the wrappings around the mummy's right thigh, the dagger was "something that he would need in the afterlife to fight against the demons, or whatever dangers the afterlife has, because the afterlife is a dangerous place," Almansa-Villatoro says. "It's also a marker of status."

Tut's dagger is one of the most expertly wrought objects of its kind, but evidence of ancient cultures using meteoritic iron has been found elsewhere in the region and the world. A likely meteoritic iron dagger from a royal tomb at Alacahöyük in Turkey predates Tut's knife by about a thousand years.

In China, a knife and a pole weapon with a dagger-ax called a *ge,* both with meteoritic iron blades, were found in the tombs of two men, possibly brothers, who ruled the Guo state in the eighth or ninth century B.C. The weapons were probably ceremonial, like those with jade blades from this time, says Kunlong Chen, a professor at the University of Science and Technology Beijing.

Similar objects—a ge and a broadax with meteoritic iron blades—were acquired by the Smithsonian Institution in 1934, reportedly from Henan Province, where there are Zhou dynasty sites. The broadax was likely made during the earlier Shang dynasty and may have been passed down as a cherished possession. These types of weapons were used around the time the Zhou state overthrew the Shang rulers and instituted the Mandate of Heaven, the philosophy that the king ruled by divine decree.

Did these rulers know the weapons were made of celestial metal? No contemporary references to meteorites have been discovered, but Chinese texts refer to eclipses and comets. "Astronomy was already quite developed by this point," says Keith Wilson, a curator at the Smithsonian's National Museum of Asian Art. "So we do know that there may well have

been kind of court astronomers, and they were watching the skies."

In North America, dozens of beads, earspools, small blades, and other objects of meteoritic iron have been discovered within the burial mounds of the Hopewell, a widespread network of cultures that traded exotic materials. Many of these objects were found at various sites in Ohio, but 22 tubular beads once strung together with shells were found in a grave dated to about 300 B.C. near what is now Havana, Illinois.

A team of researchers determined that the Havana beads were made from iron from a meteorite shower that struck some 400 miles north, near what is now Anoka, Minnesota. The raw metal from the Anoka meteorite was likely traded to the Havana center, where it was fashioned into the beads.

With no written records, it's impossible to say whether these peoples understood that the metal came from the sky. "We know a lot about the material culture," says Tim McCoy of the Smithsonian's National Museum of Natural History. "We don't know an awful lot about their belief systems."

Elsewhere, meteorites themselves provide clues about people's interactions with extraterrestrial metal. In Argentina, a field of impact craters about 500 miles northwest of Buenos Aires was created by a shower of iron meteorites roughly 4,500 years ago. In the 16th century the Spanish governor of Tucumán Province heard from Indigenous people about hunks of metal that had fallen from the sky.

Guides led Spanish soldiers to the region, reportedly called Piguem Nonraltá by the Indigenous populations and translated as Campo del Cielo, meaning "field of the sky." The soldiers found a large slab of iron but refused to believe the stories that it had dropped from above. The Indigenous people made weapons from the iron, according to Spanish reports, but none survive.

Campo del Cielo contains at least 26 impact craters. More than 110 tons of iron have been recovered from the area, including two of the largest meteorite fragments in the world—one of which, weighing 34 tons and named Gancedo after a nearby town, was discovered only in 2016. Researchers with the National University of La Plata in Argentina recently investigated whether Indigenous stories of great cataclysms could be descriptions of the impact. They didn't find a definitive link but noted that some of the tales include fire or stones falling from the sky. They also concluded the meteorite shower "was of such magnitude that it must have deeply marked the cultures in the area."

FINDING METEORITIC METAL

HOW OFTEN PEOPLE USED sky metal has proved difficult to puzzle out. Hundreds of iron objects from Bronze Age sites are listed in archaeological records, but most have not been analyzed, and many are no more than small bits of rusted metal that may have been things like pins or rings.

"If you look at what has already been excavated and how little of that even has been studied, that is a scandal," says Thilo Rehren, an archaeological scientist at the Cyprus Institute. Like many archaeologists, Rehren is interested in distinguishing between meteoritic and smelted iron, not necessarily to discover celestial metal but to figure out how and where the Iron Age began.

Civilizations in West Asia and the Caucasus Mountains began making bronze as early as the fourth millennium B.C. But most experts believe humans would not learn to reliably extract iron from ore until the end of the second millennium B.C. Smelting iron requires temperatures of roughly 2,200 degrees Fahrenheit.

"When you start making smelted iron, it's a big business, where you can be able to make weapons which are not expensive to produce," says geochemist Albert Jambon, a professor emeritus at Sorbonne University in Paris. "There is a switch from one economy to a new economy."

Jambon has spent the past dozen years tracking down iron objects from the Bronze Age and analyzing them. His research brought him to Aleppo, Syria, where he examined a spherical iron pendant found in the ancient city of Umm el Marra, in a tomb dated to 2300 B.C. It was among a woman's grave goods, which included beads of gold and stone and a piece of lapis lazuli carved into the figure of a goat, all of which may have dangled from a necklace. The museum in Aleppo also had a copper ax-head with an iron blade, dated to about 1400 B.C., discovered in the ruins of Ugarit, a port city.

Jambon measured the chemical composition of these objects with a handheld x-ray

fluorescence machine, which looks a bit like a ray gun. His analysis led him to conclude that both artifacts are meteoritic.

I met Jambon in Nicosia, Cyprus, where he was studying the island's extensive collection of early iron artifacts, which date to about 1200 B.C. This presents something of a mystery, considering the island does not have any typical iron ores, such as magnetite and hematite.

In a dusty storeroom of the Cyprus Museum, Jambon used his x-ray gun and a small magnifying glass to examine dozens of iron artifacts. *"Ooh là là,"* he murmured as he saw the first one, the end of a sickle. *"C'est vraiment bien."*

Despite his excitement, these artifacts weren't likely to be displayed. Iron rusts when exposed to oxygen, unlike bronze, which develops a green patina, or gold, which does not oxidize at all. Next to well-preserved treasures, corroding metal does not appear so striking. And none, it seemed, were made of meteoritic metal. Most were knives, but a spiral ring and a brooch served as a reminder that even after iron smelting began, the metal was considered precious.

INTERPRETING ANCIENT TEXTS

ARTIFACTS THAT COULD help piece together the puzzle of the Iron Age's origins are gradually corroding, but additional clues about iron are still being discovered in early texts.

Between the 20th and 18th centuries B.C., the Old Assyrian city-state of Assur in modern Iraq established trade colonies in what is now Turkey. Some 20,000 cuneiform tablets found at Kültepe-Kanesh, the site of the primary outpost, reveal details of this trade. The records include multiple terms connected to iron, such as the Akkadian word *parzillum,* which is also used in later periods. One of the most common, however, is the term *amūtum,* which appears with cuneiform signs that can mean "metal" and "sky."

Whether this term refers explicitly to meteoritic iron, or if it could simply be the word for a type of metal, is unclear. "Whatever it is, it's super expensive," says Gojko Barjamovic, an Assyriologist at Harvard University. The records from Kültepe-Kanesh show that this sky metal was traded for as much as 40 times the price of silver.

Parzillum appears again in two cuneiform

THE METEORITE SHOWER 'WAS OF SUCH MAGNITUDE THAT IT MUST HAVE DEEPLY MARKED THE CULTURES OF THE AREA.'





CELESTIAL DAGGER

A priest wearing a mask representing Anubis, the god of mummification, places a meteoritic iron knife with Tutankh-amun. Protection for the dangerous journey to the afterlife, the weapon could prove useful if the pharaoh had to face the giant serpent Apep. Ancient Egyptians may have understood meteorites fell from the sky and incorporated this knowledge into their religious beliefs.





FIT FOR A KING

Tutankhamun's iron dagger stands out for its excellent craftsmanship, with a blade that archaeologist Howard Carter, who led the excavation of Tut's tomb, described as "very sharp." Inlays of colorful stone and glass adorn the gold hilt, with additional bits of gold used for filigree and granulated patterns. The pommel was carved from rock crystal, a transparent form of quartz. Researchers who've studied the dagger believe the hilt may not be original since the blade's tang doesn't sit flush with the handle. One of two daggers that were discovered on King Tut's mummy, the iron implement was clearly a prized item.

PHOTO: SANDRO VANNINI
BACKGROUND: OWEN FREEMAN

tablets sent to Egypt in the 14th century B.C. The tablets, among 382 found in the ancient Egyptian capital of Amarna, describe three daggers with iron blades as well as bracelets of iron and an iron mace covered in gold.

These objects are included on lists of gifts sent from Tushratta, the ruler of the Mitanni kingdom in what is now Syria and Turkey, to the Egyptian Pharaoh Amenhotep III. Tutankhamun is believed to have been Amenhotep III's grandson, which has led some scholars to argue that Tut's iron dagger could be one of those mentioned in the lists, perhaps passed down as an heirloom.

More terms for iron appear in records from the Hittite Empire, which became the dominant power in much of present-day Turkey and Syria around the 14th century B.C. These include "good iron," "black iron," and possibly "white iron," apparently to distinguish different types. A ritual preserved in several texts describes the gods building a temple. In one version, a line states: "They brought black iron of the sky"—a possible reference to the black crust that coats meteorites after their fiery plunge through the atmosphere.

"This kind of thing does indicate that they seem to know that it's coming from the sky," says Mark Weeden, a scholar of Hittite texts at University College London.

Hittite inventories mention hundreds of iron objects, including blades, jewelry, statuettes, and a 66-pound basin. The amount of iron described in these texts, as well as descriptions of people working iron, have led some scholars to conclude the Hittites may have developed iron smelting by this point. But only about two dozen artifacts of rusty iron have been discovered at Hittite sites, and they have not been analyzed to determine if they are meteoritic, leaving the extent of ironworking at this time a mystery.



RECORD HOLDER

The Hoba meteorite outside of Grootfontein, Namibia, named after the farm where it was found, is the largest known in the world. Estimated to weigh more than 67 tons, it remains where it landed less than 80,000 years ago, according to radioactive dating. The meteorite is now surrounded by a tiered viewing area.

THE RIGHT ORDER OF THINGS

AT THE EGYPTIAN MUSEUM in Cairo, I admired two iron objects found with Tutankhamun's mummified remains that were recently confirmed as meteoritic. One is a pendant of the Eye of Horus hanging on a gold alloy bracelet, discovered near Tut's right rib cage in the wrappings. The icon is one of the most recognizable from ancient Egypt, used continuously for more than 2,000 years. It comes from an Egyptian saga of the struggles between Horus, a god of order, and Seth, a god of chaos. Seth rips out Horus's eye, which is later restored. The symbol represents a return to the right and proper state of things.

The other is a small charm in the shape of a headrest, like the full-size ones made of wood that the Egyptians used when they slept. It was found in the back of Tut's funerary mask. These headrest amulets served as symbols of rebirth. The image of a round head on a curved headrest evoked the rising sun, the god Re, who was birthed by the sky goddess Nut each morning and swallowed by her each night.

I couldn't help but wonder if the people who



made these talismans knew where the otherworldly material came from. While carefully filing the lines of Horus's eyebrow, did the artisan think about how the metal had come into his hands from the realm of the gods? When the small bit of iron was bent into the shape of a headrest, did the curved amulet remind the metalworker of the great basin in the sky?

We will never know, but we do know that descriptions of metal in the sky would endure in Egyptian writings for thousands of years. The funerary spells in the Pyramid Texts evolved into the Coffin Texts, painted on caskets inside and out. "I know the Field of Reeds of Re," reads one line repeated on several coffins, referring to a region in the sky. "The wall that goes around it is of iron."

By the 13th century B.C., a more direct way of writing "metal of the sky" came into use. Funerary spells then were written on papyrus and today are known as the Book of the Dead.

In one spell, a great fishing net is described—a barrier the deceased must navigate in their journey to the afterlife. "Do you know that I know the name of its weights?" the Book of the Dead intones. "It is the iron in the midst of the sky." ▯

Jay Bennett is a senior science editor for *National Geographic*. **Owen Freeman** is an illustrator, concept artist, and teacher. This is photographer **Paolo Verzone'**s fifth feature for the magazine.

LIVING

WOMEN'S QUEST FOR RIGHTS

IN

SHAPED THIS BRAZILIAN VILLAGE.

HARMONY

BY **PAULA RAMÓN**

PHOTOGRAPHS BY **LUISA DÖRR**





Bruna Oliveira Fernandes, one of 350 or so residents of Noiva do Cordeiro in the mountains of southeastern Brazil, likes to play with chickens and often gives them pet names. Known as Noiva, the village was founded at the end of the 19th century.





IF

YOU RECOGNIZE THE NAME Noiva do Cordeiro, you may know it as the village where everything is dominated by women, the women are all young and beautiful, they regularly send their men into exile, and then the young, beautiful women invite eligible men to ...

To a wildly fictionalized version of a real place.

Not one claim in that first paragraph is true about the actual Noiva do Cordeiro, a secluded rural community in southeast Brazil. But the titillating reports have circulated for a decade or more, ever since a few provocative articles were published, replicated by media worldwide, and permanently inscribed on the internet.

For the record: About as many men as women live in Noiva, population roughly 350. Most of the men *are* away weekly, working in a nearby city. Most of the women work in the village, which residents run communally.

The women (of all ages) take the embellishments with good humor and take pride in the true history of Noiva's women, one family line

Mothers gather with their children under a tree in Noiva. Part of the village's culture is to help each other raise the kids. "There are lots of arms to hold him," Daiane Fernandes de Araújo (second from left) says of her son.



especially. In the late 1800s a young woman defied church and society to establish the unconventional settlement. Today a 78-year-old woman—the founder's granddaughter—leads the thriving, evolving community.

MARÍA SENHORINHA DE LIMA came of age in a 19th-century Brazil steeped in Portuguese colonizers' machismo and Roman Catholicism's dogma. After three months in a forced marriage, María fled with a man she loved, Chico Fernandes; as punishment, the church excommunicated María and four generations of her descendants. María and Chico settled on land in the state of Minas Gerais. More people joined them, including other women cast out by the church; a community grew, shaped by gender equality and freedom of religion.

But the excommunication haunted the settlement's families. Women branded "sinners" couldn't safely leave the village; when children tried to go to school in neighboring towns, they were called "prostitutes' daughters" and shunned. "It was very sad," remembers Marcia Fernandes, one of María's descendants. Still, the village stood for decades as an outpost of tolerance, welcoming the nonconformist, the unrepentant, the outcast.



THAT CHANGED WITH the arrival in the 1940s of Anisio Pereira, a Protestant evangelist who based his version of Christianity on a literal reading of Scripture. He started a church and offered salvation to onetime Catholics who obeyed him; he restricted alcohol and music, and ordered that women be subordinate to men in all things. As his dominance rose in the 1960s, the 45-year-old preacher took a 16-year-old wife: Delina Fernandes, a granddaughter of María.

"It was harsh, very hard," says María Doraci de Almeida, 75, who lived under the Pereira leadership. "We women had no say. You could not

LEFT
An old photograph shows early residents of the village established by María Senhorinha de Lima (front, third from right) after she ran off with her lover, Chico Fernandes.

RIGHT
Delina Fernandes, 78, sits for a portrait with some of her 15 children. She's María Senhorinha's granddaughter and has led the Noiva community since 1995.



take contraceptives or have a cesarean section. Delina had her children at home, 15 children, without a midwife. On one occasion, she had her daughter at five in the morning, and two hours later she was already cleaning a pig in the slaughterhouse."

Pereira named his church with a tender religious metaphor: Bride of the Lamb, *Noiva do Cordeiro.* But Rosalee Fernandes Pereira, 58, Delina's third daughter, says now that her father was "very fanatical." His teachings, she says, were not "the ones that were going to take us to the kingdom of God." Yet he was never deposed from leadership.

When Pereira died in 1995, his church was closed and demolished. The village retained Noiva do Cordeiro as its name—but to cement the change in lifestyle, one of Pereira's sons later opened a tavern across the street.

Delina rose to lead the community. Her approach empowered village women yet didn't seem to upset village men.

"The women here are hard workers. We value them. They are strong; they are examples to follow," says Marcos Fernandes, who, with his brother Eduardo, takes care of the village's chickens. "Senhora Delina, for example, is our greatest influence. I can't imagine life without her. Her presence is so strong that I feel it without seeing her."



Residents harvest crops that provide food and income for the community. Here they pick kale, which they also use to feed livestock. Agricultural work is one of the shared duties that benefit everyone.

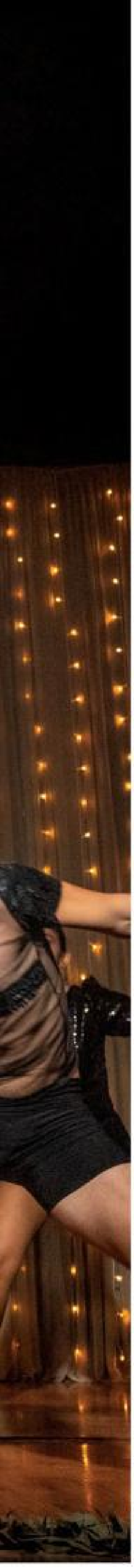
SOREN WALLJASPER, NGM STAFF





‘We have neither wealth nor money, but we have abundance.’

DELINA FERNANDES,
NOIVA COMMUNITY LEADER



LEFT

Keila Fernandes (front) performs a musical act inspired by Lady Gaga, which has garnered attention beyond the village with performances in São Paulo and Rio de Janeiro. "To go on stage and see their faces full of love and admiration makes me feel such immense happiness," she says. "It is magical."

TOP RIGHT

Some of Keila's costumes hang on a clothesline. Residents were exposed to artists such as Lady Gaga in 2006, when the internet became accessible. Community performances on a range of topics are now held every Saturday.

BOTTOM

Natalia Fernandes Emediato celebrates her 10th birthday with a party that includes her parrot, Pitty. She also has a pair of fish and parakeets, and she sings with the village chorus.









Delina is widely credited with making Noiva once again an inclusive community. In response to growing poverty at the end of the 1990s, she proposed that everything in the village be shared, including the work required for harvesting. “We didn’t have anything; what else could we do?” she says.

The residents bought a large parcel of land near Noiva, where they cultivate 3,500 *mexerica* (mandarin) trees and seemingly endless rows of coffee plants, the community’s main commercial crops. They also tend to a vegetable garden and communally owned farm animals. Many homeowners have their own vegetable gardens too, from which they contribute to the community pot. Villagers are assigned duties such as fetching firewood, sewing, and cleaning the shared spaces.

“It worked,” Delina says with pride. “We have neither wealth nor money, but we have abundance.” Today she spends much of her time in the village’s central Mother House, sitting in the kitchen, sipping coffee and cutting cabbage to be fed to the chickens. There she also listens to residents who come to her with their troubles and dispenses advice.

SEVERAL YEARS AGO, a young man named Erick Araújo Vieira returned to Noiva. He’d grown up there and moved away at age 18 to attend university in the state’s capital, Belo Horizonte. When he came home, he went to see Delina and told her he was gay. At the time there were no openly gay men in Noiva. He feared rejection, she says. “He came crying to tell me that he knew it was a sin, that he would not go to heaven. I told him to get that out of his head.”

Delina suggested to her daughters Keila and Marcia that they produce a play addressing questions about sexual identity and orientation. The play helped generate discussion and acceptance in the community. Vieira’s parents spurned him at first, but their relationship later improved, helped by the more open attitudes of others in the village. “When he came with a boyfriend, the

Wearing formal attire for a portrait, Alexsander Estéfano Moreira Morais helps his partner, Marco Antonio Fernandes Emediato, fix his bow tie. In a country with one of the highest rates of violence against LGBTQ+ people, Noiva is a refuge.










'The women here are hard workers. We value them. They are strong; they are examples to follow.'

MARCOS FERNANDES, NOIVA VILLAGER

Residents pitch in to keep the community running.

TOP LEFT

Lucinete Fernandes Emediato works in the vegetable garden. "It is a privilege," she says. "I adore taking care of the plants."

TOP RIGHT

Mario Pereira Lima is responsible for slaughtering animals to feed the residents.

BOTTOM LEFT

Raul Rodrigues Vieira Leite enjoys milking the cows early in the morning. He dreams of becoming a cowboy.

BOTTOM RIGHT

Angela Fernandes Morais, picks *mexericas* (mandarins). Her mother, a performer, has inspired Angela to become a dancer.

Workers gather mexericas that, along with coffee, constitute Noiva's main commercial crops. Residents are assigned duties as part of communal living that sets this village apart from the rest of Brazil. "We didn't have anything; what else could we do?" says community leader Delina Fernandes, who proposed everything be shared in response to growing poverty at the end of the 1990s.



elders understood it," says Marcia. "He kind of paved the way for the others, like my son, who came out afterward."

Community performances are now held every Saturday. They range from comedies and shows based on current events to a Lady Gaga-inspired musical act that's earned attention beyond the village, performing in São Paulo and Rio de Janeiro.

Though Rio is barely a six-hour drive away, villagers are seemingly so content that most express no desire to leave their home. Noiva feels like a refuge from life's toxic ways, where collaboration is preferred to competition and discord gives way to harmony.

WHY NOT PLAY ALONG with the joke? Many in Noiva did when visiting journalists wrote that it was a village with few men, ruled by Amazon-like females, and where milk and honey flowed. Headlines such as "Lost Village of Brazilian Women Appeals for Single Men" attracted suitors from around the world, and film crews sought to recruit Noiva women for reality-TV shows.

"When the reporters came, I used to send the men away" to maintain the fiction that only women lived in Noiva, matriarch Delina jokes. Her daughter Marcia laughs and adds, "With that story of gringos coming to look for wives, the men here felt threatened and they all got married. Even the ones who were dragging their feet."

Delina's daughter Rosalee sees a point behind the media hype. To outsiders, Noiva women may appear to dominate the men—but in reality, "what happens is that here there is true equality," she says. "In the rest of the world, there is not.

"Here we are human beings. It is so simple that it is hard to explain." ◻

Venezuelan writer **Paula Ramón** is a regular contributor to *National Geographic*. Brazilian photographer **Luisa Dörr** works on stories about women and cultural traditions.


SALMO 91



INSTAGRAM

HAO JIANG

FROM OUR PHOTOGRAPHERS

WHO

A California-based hobbyist photographer focusing on nature

WHERE

Mexico's Ría Lagartos Biosphere Reserve

WHAT

Nikon D850 camera with a 500mm lens

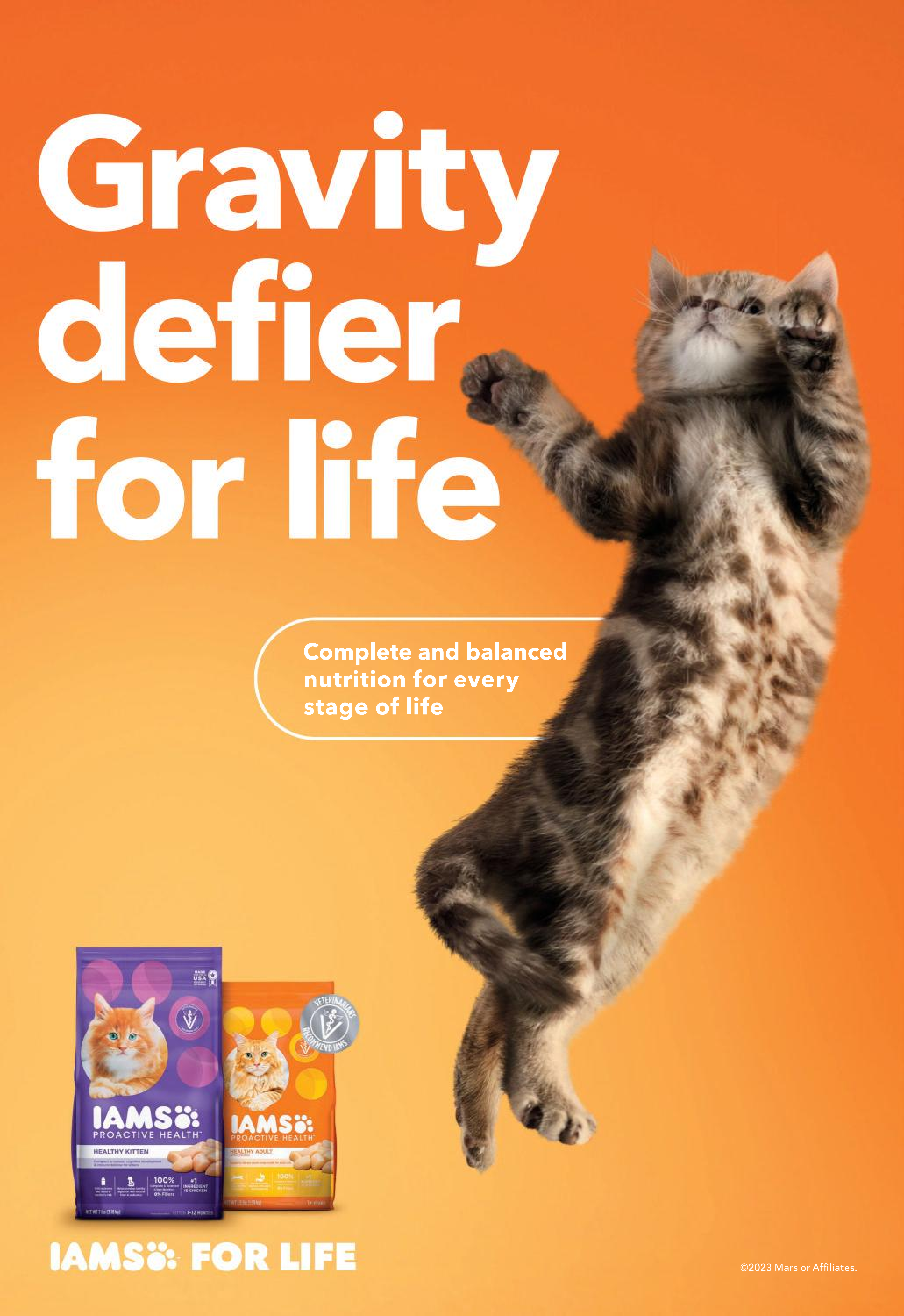
Jiang wanted to capture images of flamingo chicks—but it was harder than she expected. After traveling to the Yucatán Peninsula, known for its flamingo breeding grounds, she was escorted by rangers inside the Ría Lagartos Biosphere Reserve. They set off before dawn, waded through a 300-foot stretch of water, and waited in a blind until sunrise. In the early light Jiang spotted the chicks, just a week or two old. She was charmed by their "fluffy gray feathers, which are so different yet harmonious with their parents' colors."

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